TACTICAL RADIO SYSTEMS

Subcourse Number SS0014

EDITION A

United States Army Signal Center and School
Fort Gordon, Georgia 30905-5074

5 Credit Hours

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SUBCOURSE OVERVIEW

This subcourse presents the basic theory of radio operation, the different types of tactical radios currently in use, and basic tactical radio communications procedures.

There are no prerequisites for this subcourse.

This subcourse reflects the doctrine which was current at the time it was prepared. In your own work situation, always refer to the latest official publications.

Unless otherwise stated, the masculine gender of singular pronouns is used to refer to both men and women.

TERMINAL LEARNING OBJECTIVE

ACTION:	You will learn the application of the various tactical radio configurations currently available. This includes component units for the configurations and auxiliary equipment needed to construct each configuration. You will also learn the organization of tactical radio communications in the various elements of the division, and the differing equipment requirements for each element.
CONDITION:	You will be given information from this subcourse.
STANDARD:	To demonstrate competency of this task, you must achieve a minimum score of 70% on the subcourse examination.

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FM 11-32 Combat Net Radio Operations, October 1990.

FM 24-18 Tactical Single-Channel Radio Communications Techniques, September 1987.

TC 24-24 Signal Data References: Communications-Electronics Equipment, October 1988.

Use the above publication extracts to take this subcourse. At the time we wrote this subcourse, these were the current publications. In your own work situation, always refer to the latest publications.

LESSON 1

EMPLOYMENT OF TACTICAL RADIO SETS

CRITICAL TASKS: S1-5878.04-9001, 01-5704.04-9001, 01-5704.07-0001

OVERVIEW

LESSON DESCRIPTION:

In this lesson you will learn how to configure the various tactical radio sets available and how to select a particular set for a given communications task. You will also learn the field expedient measures used to repair or replace damaged antennas, or to configure an antenna for a specific task.

TERMINAL LEARNING OBJECTIVE:

ACTIONS:

a. Identify suitable radio and control equipment for a specific communications system requirement.

b. Describe the type of tactical radio system that will best meet the requirements of the commander, including modern single-channel ground and airborne radio system (SINCGARS) and improved high frequency radio (IHFR) radio sets.

c. Identify when and what equipment is needed to install a tactical radio retransmission station.

d. Identify tactical communications requirements to determine whether a point-to-point tactical radio network will provide the required communications.

e. Describe the steps to fabricate a whip, ground plane, doublet, half-rhombic, and long wire antenna.

CONDITION: You will be given information from this lesson.

STANDARD: To demonstrate competency of the terminal learning objective, you must achieve a minimum score of 70% on the subcourse examination.

REFERENCES: The material contained in this lesson was derived from the following publications: FM 11-32, FM 24-18, and TC 24-24.

INTRODUCTION

The modern battlefield is a huge place that can span thousands of miles over virtually impassable terrain. It can also extend from below the ground to outer space. Radio communications is the only hope that a modern commander has of maintaining perspective (and thus control) over such a vast area.

The communications tasks involved are many and varied, and require every resource that the modern signal officer can bring to bear in support of this effort. As that signal officer, it is vital that you be familiar with the equipment and personnel at your disposal, and that you be able to use whatever equipment is best suited for any given communications situation. The following paragraphs outline the capabilities and uses of several pieces of modern tactical communications equipment. Some of the equipment discussed may not be widely in circulation any more, but it is important that you be familiar with it nonetheless. You never know when you may be forced to use an old piece of equipment as a backup to a new piece that fails unexpectedly. Appendix B is equipment annexes that provide drawings of most of the equipment presented here. Refer to these drawings as you read about the various pieces of radio equipment. This course is not designed to provide in-depth knowledge about the operation of individual equipment, and should never be used as a replacement for the equipment technical manuals.

1. Radio Sets AN/PRC-25, AN/VRC-53, and AN/GRC-125.

This family is the earliest group of FM transmitter-receiver radio sets still in use. All three versions utilize the receiver-transmitter (RT) -505 receiver-transmitter operating in the lower very high frequency (VHF) band (30 to 52.95 megahertz (MHz) and 53 to 75.95 MHz). The PRC-25 is a portable manpack version. The VRC-53 adds amplifier OA-3633 to make a vehicular-based unit, and the GRC-125 is a portable or vehicular based model. All three configurations are used for short-range communications. This family of radio sets has no secure transmission capability.

2. Radio Sets AN/PRC-77, AN/VRC-64, and AN/GRC-160.

This family of radio sets is replacing the PRC-25, VRC-53, and GRC-125 series respectively. The transmission characteristics are exactly the same as the earlier radio sets. The difference is that the newer sets use receiver-transmitter RT-841 which is completely transistorized. Another feature incorporated into the new sets is the capability of secure voice transmission using the VINSON device.

3. AN/VRC-12 Family of Radio Sets.

The radio sets in the AN/VRC-12 family are short-range vehicular and fixed radio sets designed for general tactical use. They provide frequency modulation (FM) voice communications and can be used with secure voice and digital data equipment using the X MODE facility or VINSON. Two of the sets (AN/VRC-45 and AN/VRC-49) have retransmission capability. The radio sets of the AN/VRC-12 family will net with each other and with other FM radio equipment operating in the 30 to 75.95 MHz frequency range. Each of the eight configurations in this family is made up of a combination of receiver-transmitters RT-246/VRC and RT-524/VRC and receiver R-442/VRC along with support equipment. Table 1-1 shows the equipment configurations for each of the various AN/VRC-12 series radios.

Name	RT-246	RT-442	RT-524	C-2299	Antenna
AN/VRC-12	1	1	0	0	2
AN/VRC-43	1	0	0	0	1
AN/VRC-44	1	2	0	0	3
AN/VRC-45	2	0	0	1	2
AN/VRC-46	0	0	1	0	1
AN/VRC-47	0	1	1	0	2
AN/VRC-48	0	2	1	0	3
AN/VRC-49	0	0	2	1	2

Table 1-1. AN/VRC-12 family configurations

a. Receiver-Transmitter RT-246/VRC and RT-524/VRC. These two receiver-transmitters are the heart of the AN/VRC-12 family of radios. They operate in two bands; Band A - 30 to 52.95 MHz, and Band B - 53 to 75.95 MHz. They are capable of transmission up to about 41 kilometers (km). Each member of the AN/VRC-12 family contains at least one of these units. The primary differences between the two units are that the RT-246 has ten automatic channel presets and the RT-524 has a built-in loudspeaker.

b. Receiver R-442/VRC. This receiver is used in several of the AN/VRC-12 configurations to allow monitoring of one net while transmitting in another. The R-442 operates in the same frequency range as the RT-246 and RT-524.

This configuration includes one RT-246, one R-442, and two antennas. You can use this configuration to monitor one net while you conduct communications in another. You can easily switch transmitting frequencies of the R-246 to transmit in the R-442's net.

This configuration consists of one RT-246 and one antenna and it is used for communications in a single radio net.

This configuration consists of one RT-246, two R-442s, and three antennas. With this set you can communicate in one net and monitor two additional nets. As with the VRC-12, you can change transmitting frequency on the RT-246 and transmit into either of the other two nets.

This configuration consists of two RT-246s, two antennas, and a C-2299/VRC Retransmission Cable Kit. You should use this configuration to provide retransmission facilities for two stations that are too far apart to talk to each other directly. You can also use this set to retransmit information from one net into another net by tuning the two RT-246s to different frequencies. The MK-456/GRC cable kit can also perform the retransmission functions for the AN/VRC-45 if the C-2299/VRC cable is not available.

This configuration uses one RT-524 and one antenna and is essentially identical in function to the AN/VRC-43.

This configuration uses one RT-524, one R-442, and two antennas; It functions the same way as the AN/VRC-12.

This set consists of one RT-524, two R-442s, and three antennas. It functions the same way as the AN/VRC-44.

This configuration consists of two RT-524s, two antennas, and the C-2299/VRC. It serves the same retransmission functions as the AN/VRC-45.

All the AN/VRC-12 family configurations are secure voice capable. You can secure the sets using either VINSON (KY-57) or NESTOR (KY-38) secure devices.

4. Radio Set Control AN/GSA-7.

The AN/GSA-7 is an electronic switching device. You use it to interface FM radio equipment with local push-to-talk wire telephone circuits. The GSA-7 is the basis of the net radio interface (NRI) system. The unit acts as an automatic keying device so that when a remote telephone operator keys his telephone set he also keys the transmitter of the FM radio set. This allows his wire telephone message to transmit over the FM frequency to a receiver that can also be attached to another GSA-7 to convey the message into another wire telephone net at a remote site. You can control a radio set with the GSA-7 from as far away as 16 km (10 miles (mi)).

5. Control Group AN/GRA-6.

Occasionally you may want to locate your radio transmitter in a site where communications are good, but the site does not offer a good tactical position. When this happens the best thing to do is set the radio up so you can operate it remotely. The GRA-6 is the piece of equipment that allows you to do this. The GRA-6 consists of a local and remote unit used at the radio site and the remote control site respectively. The two units are connected by field wire and can be separated by up to 3.2 km or 1.5 miles.

6. Radio Set Control Group AN/GRA-39B.

The GRA-39B is another remote control set similar to the GRA-6. It also is used with FM radio sets and has a range of 3.2 km. The principal difference between the GRA-39B and the GRA-6 is that the 39B is fully transistorized and the 6 is not.

7. Retransmission Cable Kit MK-456A/GRC.

This kit is used with the AN/PRC-25 and AN/PRC-77 series of radios for retransmission. You can also use it with the AN/VRC-12 series if the standard C-2299/VRC kit is unavailable.

8. Radio Set AN/GRC-19.

The AN/GRC-19 is a medium-power voice and continuous wave radio set designed for vehicular installations. It forms the central unit for several of the older radio teletypewriter (RATT) sets. The GRC-19 is being phased-out of use and replaced with the newer GRC-106 radio set. You can also use the-GRC-19 to perform retransmission functions. Both transmitter and receiver operate in the high frequency (HF) band. The transmitter operates between 1.5 and 20 MHz, and the receiver operates

between 0.5 and 32 MHz. The AN/GRC-19 operates in amplitude modulation/double sideband (AM/DSB) mode.

9. Radio Set AN/GRC-106.

As stated previously, the AN/GRC-106 is replacing the AN/GRC-19 in its mobile retransmission role. It is also the central unit for the newer family of radio teletypewriter sets currently in use. The GRC-106 operates in the HF band between 2.0 and 29.999 MHz and uses the amplitude modulation/single sideband (AM/SSB) mode. There are two basic configurations of this equipment, the GRC-106 and GRC-106A. The former uses receiver-transmitter RT-662/GRC which has a channel spacing of 1 kilohertz (kHz). The 'A' variation uses receiver-transmitter RT-834/GRC which has channel spacing of 100 hertz (Hz). You can see from this that the 'A' variation has ten times as many channels available as the standard GRC-106. The AN/GRC-106 has both voice and continuous wave (CW) capability.

10. Radio Set AN/FRC-93.

The FRC-93 is a commercial type of AM/SSB (upper or lower) radio set adapted for military use. You can also perform CW communications using the FRC-93. The radio set operates in two regions of the HF band, from 3.4 to 5.0 MHz and from 6.5 to 30 MHz. This type of radio set uses crystal sets for tuning.

11. Radio Set AN/PRC-74.

The AN/PRC-74 is a low-power, transistorized AM/SSB/upper sideband (USB) radio set designed for voice and CW communications. The PRC-74 is configured as a manpack and is primarily designed for communications in areas where line of sight (LOS) communications is not possible due to terrain or other obstructions. The AN/PRC-74 comes in four variations: basic, A, B, and C. The basic and A versions operate between 2.0 and 11.999 MHz. The B and C versions extend the upper frequency limit to 17.999 MHz. The AN/PRC-74 adds the versatility of being able to communicate with remote sites that you could not communicate with using the AN/PRC-25 or 77 series of FM radios.

12. Radio Set AN/PRC-70.

The AN/PRC-70 was originally designed to give special forces, ranger, long-range reconnaissance patrol, and selected engineering units a lightweight multimode means of communications. The unit operates over a range of 2.0 to 75.999 MHz in the HF and very high frequency (VHF) bands. The PRC-70 can operate in AM/DSB, AM/SSB, FM, CW, and frequency-shift keying (FSK) modes. This flexibility allows the unit using this device to travel almost anywhere they need to go and still be able to provide real-time intelligence information to command and control units in the corps and theater areas. The AN/PRC-70 usage has been expanded to battalion communications stations as well as forward deployed units. The AN/PRC-70 can be operated in secure mode using both VINSON and NESTOR secure devices. Another great advantage of the PRC-70 is that it can communicate with any of the AM, AM/SSB, or FM radios discussed previously in this lesson. You can also set up retransmission stations using the PRC-70 and the MK-456/GRC control cable. The combination of its light weight, ruggedness, and wide range of capabilities makes the AN/PRC-70 an ideal radio set for units that require great freedom of movement and activity. In a fixed site, one AN/PRC-70 can serve as a backup for almost all other tactical communications systems.

13. Teletypewriter Set AN/PGC-1.

The PGC-I is the most basic RATT system currently in use. It is a small transportable unit consisting of a keyboard and a printing device. The PGC-1 is used in fixed and transportable configurations.

14. Teletypewriter Set AN/FGC-20.

The FGC-20 is similar to the PGC-1 with the exception of being larger and more durable. This unit is found primarily in fixed sites where portability is not a requirement.

15. Radio Teletypewriter Sets AN/GRC-46, AN/VSC-1 and AN/VRC-29..

The GRC-46, VSC-1, and VRC-29 are older RATT sets that are used in mobile communications applications. They all use the AN/GRC-19 radio set as the basic transmitter-receiver, and they have the same operating frequencies and modes as that unit. The Army is replacing these units with the AN/GRC-106 based RATT sets.

a. GRC-46. The GRC-46 consists of one GRC-19 and two teletypewriter units. One of these units is a tape reperforator type unit. The GRC-46 is shelter-housed and found in 3/4-ton mobile communications stations.

b. VRC-29. The VRC-29 is identical to the GRC-46 except that it is not shelter-housed. This version is carried in armored personnel carriers (APCs).

c. VSC-l. The VSC-1 contains the AN/GRC-19 and a single teletypewriter (non-reperforating). This set is designed to be lightweight and is carried in jeeps.

16. Radio Set AN/GRC-26D.

The GRC-26D is a high-power RATT station designed for use in fixed, semifixed, or mobile applications. The set consists of a transmitter, two receivers, and three teletypewriters. The GRC-26D operates in the same frequency bands and operational modes as the GRC-46 family. In its mobile configuration, the GRC-26D is shelter-mounted in a 21 ton vehicle. The GRC-26D is generally considered obsolete and has been replaced in regular units by the GRC-106 based AN/GRC-122.

17. Radio Teletypewriter Sets AN/GRC-122, AN/GRC-142, AN/VSC-2 and AN/VSC-3.

These RATT sets are replacing the older AN/GRC-19 based systems described previously. They are based on the more modern and versatile AN/GRC-106 transmitter-receiver, and they have the same frequency and mode characteristics as that equipment. The following paragraphs briefly discuss the differences in each of these pieces of equipment.

a. AN/GRC-122. The GRC-122 has replaced the AN/GRC-26D as the long-distance shelter mounted RATT station for fixed, semifixed, and mobile applications. It consists of two receiver-transmitters and three teletypewriters. The GRC-122 is much lighter than the GRC-26D and can be carried on a 3/4 ton vehicle.

b. AN/GRC-142. The GRC-142 is replacing the AN/GRC-46 in the 3/4 ton vehicular installations. In addition to the ability to use AM/SSB, the GRC-142 also has the added ability to perform secure voice

communications which the older equipment does not. The GRC-142 consists of one receiver-transmitter and two teletypewriter units.

c. AN/VSC-3. The VSC-3 is replacing the AN/VRC-29 for installation in armored personnel carriers. The set consists of one receiver-transmitter and two teletypewriters. Except for being shelter-mounted, the VSC-3 is essentially identical to the GRC-142.

d. AN/VSC-2. The VSC-2 is replacing the VSC-1 as the jeep-mounted version of the RATT set. Like its predecessor, the VSC-2 consists of a receiver-transmitter and a non-reperforating teletypewriter. As with the more robust members of its family, the VSC-2 is capable of AM/SSB secure voice communications.

18. SINCGARS.

SINCGARS equipment is replacing the AN/PRC-77 and AN/VRC-12 series equipment currently in use. SINCGARS is a modular system, allowing components of one piece of equipment to serve as replacements for another. This feature provides increased reliability of communications overall. SINCGARS has two basic modes of communication: single-channel or frequency hopping (FH). In the single-channel mode, it can communicate with any of the older VHF-FM equipment currently in use. In this mode, SINCGARS equipment can hold up to eight single-channel frequencies. When you shift the SINCGARS equipment to FH mode, it shifts operating frequencies about 100 times per second in the 30-88 MHz range. The audio signal is then modulated on the shifting carrier to produce an output signal that moves about the VHF spectrum. This "hopping" of the frequency makes the signal very difficult for enemy forces to detect, locate, or jam. If the changing of frequencies was completely random, there would be no way for two sets to communicates The receiving set has to change frequencies in the same manner as the transmitter. To accomplish this synchronous frequency hopping, the SINCGARS equipment stores up to six separate hopsets. Each hopset is a code that tells the unit how and when to change frequencies in a repeating pattern. In order to establish communications, two stations would make contact in single-channel mode and then switch to their designated hopset to conduct FH operations. As with the single-channel presets, the SOP defines the hopsets to be stored. One additional feature of SINCGARS equipment that makes it better than its predecessors is the ability to control output power of the unit. You can change power settings to transmit from 300 meters to 35 km (22 mi). This feature is advantageous both in field applications where detection is undesirable and in command post applications where many radios are operated simultaneously. You should always take care to operate at the minimum power required to ensure effective communications. The following paragraphs will describe the components and some of the various configurations of SINCGARS equipment.

a. Receiver-Transmitters RT-1523 and RT-1439. All ground-based SINCGARS configurations use either the RT-1523 or the RT-1439 as the basic component. Both units transmit and receive between 30 and 79.999 MHz. Both units are capable of FM, FSK, FH, and digital data input modes of operation. The RT-1523 has an internal integrated communications security (ICOM) module built into it. The RT-1439 is a non-ICOM radio but it can be secured using the KY-57 VINSON secure device. As stated previously, both units can store up to eight single-channel presets and six hopsets. While in FH mode,

the units will also receive a manual frequency. This frequency is used to allow other radios to contact the net and join after the net has been established.

b. Manpack Radio AN/PRC-119. This SINCGARS manpack radio is replacing the AN/PRC-25 and AN/PRC-77 manpack radios currently in use. The unit consists of one receiver-transmitter and a battery pack. If you use the RT-1439 then you must also use the VINSON security device.

c. Vehicular Short-Range Radio AN/VRC-87. The VRC-87 is replacing the AN/GRC-53 and AN/GRC-64 as the short-range vehicular tactical radio. This unit is essentially the same as the PRC-119 with extra cabling and no battery.

d. Dismountable Short-Range Radio AN/VRC-88. The VRC-88 adds the components to the VRC-87 necessary to make it a portable unit. This unit is replacing the AN/GRC-125 and AN/GRC-160.

e. Vehicular Long-Range/Short-Range Radio AN/VRC-89. The VRC-89 adds a second receiver-transmitter and a power amplifier to the VRC-87 configuration. This configuration allows the unit to monitor one net while communicating in another. This configuration is replacing the AN/VRC-12 and AN/VRC-47 configurations.

f. Vehicular Long-Range Radio AN/VRC-90. The VRC-90 is essentially a VRC-87 with a power amplifier added for long-range capability. The VRC-90 is replacing the AN/VRC-43 and AN/VRC-46.

g. Vehicular Short-Range/Long-Range Dismountable Radio AN/VRC-91. This unit is essentially identical to the VRC-89 except that it adds the necessary components to be operated as a manpack radio, providing manpack long-range capability. The VRC-91 does not replace any current equipment. The closest current configuration would be an AN/PRC-77 and either a VRC-43 or a VRC-46 in the same vehicle.

h. Vehicular Dual Long-Range/Retransmission Radio AN/VRC-92. The VRC-92 replaces the AN/VRC-45 and AN/VRC-49 as the vehicular station capable of acting as a retransmission station. It is the same as the AN/VRC-89 with an additional power amplifier. This configuration provides high-power capability for both receiver-transmitters.

i. Intravehicular Control Unit (IVRCU) C-11291. This device allows the operator to control up to three separate radios in armored vehicles. It can control all radio functions and can be used with ICOM and non-ICOM radios. The unit can also be set up so that three different operators can control the radio from their respective positions in the vehicle.

j. SINCGARS Remote Control Unit (SRCU). This device allows you to remotely operate your radio from up to 4 km (2.4 mi) away. The SRCU allows for secure remote operation including the control lines from the radio to the SRCU. It also provides intercom facilities between the radio and the remote site. All radio functions can be controlled remotely with the SRCU. The AN/GRA-39 can also be used to remotely control SINCGARS radios, but it only allows remote keying of the radio set.

k. Data Fill Devices MX-10579 and MX-18290. Data fill devices contain hopset and transmission security key (TSK) information for use with SINCGARS in FH mode. The TSK information actually tells the unit how to control the frequency hopping sequence. The MX-10579 holds up to 13 hopsets and 2 TSKs and you must use it with non-ICOM radios only. The MX-18290 holds 13 hopsets and 6

TSKs. Currently, you must have two fill devices to operate a secure SINCGARS radio in FH mode. One fill device is needed to load the radio and the second loads the security device (VINSON or ICOM).

l. VINSON and ICOM Secure Devices. Secure devices provide the means for secure voice communications between remote stations. The ICOM device is built into the ICON transmitter. It contains one traffic encryption key (TEK) for each hopset. This means that in addition to frequency changing constantly, the information being passed is also encrypted. The VINSON device is an external device and is used with the non-ICON radios. It has six preset positions, five for TERs and one for a key encryption key (KEK). The five TEKs used with the radio allow secure operations in up to five different networks at one time. The KES allows the VINSON device to be loaded by over-the-air (radio transmission), fill. In other words, several field units could carry VINSON devices and not carry any encryption codes. A transmitter located at a safe location could transmit the TEK information to all field units simultaneously. Thus, the units could set up secure networks without carrying any cryptographic codes with them. Both the VINSON device and the ICOM radio set are considered cryptographic material and should be destroyed if a unit possessing them is overrun.

19. <u>IHFR</u>.

The IHFR system is another new-technology modular system being introduced into operation. The system is designed to replace the AN/PRC-70, AN/PRC-74, and AN/GRC-106 systems currently in operation. The following paragraphs describe the major components and configurations for IHFR equipment.

a. Receiver-Transmitter RT-1209. The heart of the IHFR system, RT-1209 is an AM/SSB (USB or lower sideband (LSB)) radio set. It is compatible with the AX/SSB sets currently in use but is not directly compatible with the older AM/DSB equipment. An experienced DSB operator may still be able to pick up the SSB transmissions however. The RT-1209 operates between 2 and 30 MHz in the HF-band.

b. Manpack Radio AN/PRC-104A. This portable unit will replace the AN/PRC-70 and AN/PRC-74 radios currently in use. It consists of a basic receiver-transmitter and support equipment. The PRC-104A also uses a tunable antenna and has an automatic antenna tuning feature built into the unit.

c. Low-Power Vehicular/Manpack Radio AN/GRC-213. The GRC-213 combines the features of the older GRC-106 into a unit capable of vehicular or manpack use. Depending on the application, different amplifiers, power supplies, and antennas are attached. An important note on these radio sets is that your operators should always avoid excessive keying of the radio. The low-power IHFR radio has a maximum key down time of one minute and a ratio of one minute transmit to nine minutes receive. Exceeding this key down time can damage the radio set.

d. High-Power Vehicle Radio AN/GRC-193A. The GRC-193A is a basic RT-1209 with a high-power supply and support components. The AN/GRC-193A is replacing the AN/GRC-106.

20. Retransmission Stations.

When two stations that are far apart need to communicate, one way they can do so is to use more powerful transmitters. This is not desirable because it increases the electromagnetic signature of both stations and makes them more susceptible to enemy action. Another way for two remote stations to communicate is to use a retransmission station. A retransmission station consists of two radio sets and some type of interconnecting device. You have already learned about the AN/VRC-45 and -49, the AN/PRC-70, and the AN/VRC-92 SINCGARS retransmission sets. You have also learned about the C-2299/VRC and the MK-456/GRC retransmission cable kits used with these radio sets. In order to better understand the actual process of using a retransmission station, it is also important for you to understand a few details about the retransmission process.

a. Interference Elimination. A retransmission station consists of two radio stations physically located in close proximity. The radio stations are of the same type (single-channel, SINCGARS, etc.). This has the obvious drawback of being the ideal situation for cosite interference. To avoid this, your frequency planners should ensure that the two radios used for retransmission functions are assigned frequencies at least 10 MHz apart. Also the two antennas for the retransmission station should be physically located as far apart as possible. In a vehicular or airborne retransmission station, this is obviously not very far. Similarly, timesharing is not a viable option since both radios must operate simultaneously in order for the station to function properly. This leaves frequency separation as the only means of eliminating cosite interference.

b. Retransmission Mode. All the retransmission sets you have learned about can perform their functions in the VHF-FM single-channel mode. The AN/VRC-92 can also perform retransmission functions in the FH mode or in a combination of single-channel to FH modes or vice versa.

c. Employment. Although the primary use for a retransmission station is to extend the range of a medium powered radio set, it also has other uses that you should be aware of. Sometimes you may be in a headquarters that is geographically screened from forward units by a high hill in order to protect it from enemy fire. The geographical situation makes it impossible for you to communicate with forward groups using VHF-FM. If you establish a retransmission station on the top of the hill, however, both your radio station and the radios of forward units will be able to transmit to the retransmission station, and thus to talk to each other. Another infrequent use of retransmission stations is to provide NRI functions. You will learn more about the NRI system in lesson 3.

21. Types of Tactical Radio Operation.

The operation of tactical radio systems falls into three basic categories: point-to-point, networks, and net radio interface. You already know about tactical radio networks and NRI will be covered in Lesson 3. This section will teach you about the third category, point-to-point operation.

As a communications officer, you may occasionally encounter situations where you would like to set up a dedicated communications channel for just one station. This type of operation is called point-to-point communications. Point-to-point has the advantage of placing you in direct contact with a particular station at a moment's notice. The operator at the remote station has only to key his radio to talk to you. He does not have to worry about entering a network or obtaining permission to pass traffic;

he just does it. This type of setup is excellent for communications with a vital intelligence station that needs to pass emergent intelligence information directly to headquarters as soon as possible. In the modern battlefield, rapid reporting of intelligence can determine courses of events on a very large scale. Point-to-point communications also has its drawbacks. Since only one station has access to the communications frequency, the channel may sit idle for significant periods of time. This is not efficient use of the electromagnetic spectrum. Given the potential importance of a point-to-point system, however, the disadvantages are outweighed by the benefits.

22. Field Expedient Antennas.

While you are field-deployed it will happen that some portion of your antenna will break. It may be the radiating element, the antenna mast, or simply an insulator. It is important that you be ready for this, and that you be able to improvise replacements for the failed component so that you do not lose communications capability. The most important thing to remember is that when a particular item breaks, look around for items with similar physical and electrical properties to replace it. Figure 1-1 will give you an idea of the wide variety of items you can use to replace things like broken insulators. A knife or bayonet can also serve as a good substitute for a ground stake that has been lost or broken. You can repair a broken whip antenna by attaching a length of wire to it to make its total length a quarter wavelength again. Even if you do not break your antenna, you may find that you have need of a different type of antenna from the one you are carrying. For example, enemy jamming or high radio frequency (RF) noise levels may dictate the use of a directional antenna when all you are carrying is a whip antenna. Remember, the best tools to have in an emergency situation are your knowledge and your imagination. The following paragraphs will teach you the basic steps to fabricate some of the more common types of field antennas and in what situation each might be useful.

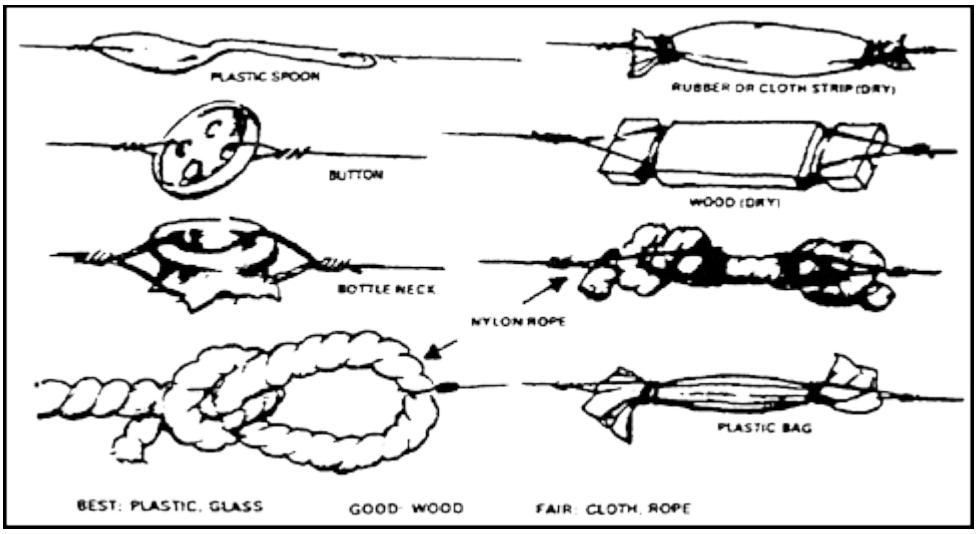

Figure 1-1. Field expedient insulators

a. Antenna Length. The length of an antenna is a very important factor to consider when you are planning communications. The length of an antenna determines what frequencies it will transmit and receive efficiently. Antennas have two lengths: physical length and electrical length. Because of the reduced velocity of the radio wave on the antenna and the capacitive effect of the end of the antenna, the electrical length of the antenna is generally longer than its physical length. Thus, if you are

designing an antenna for a specific communications task, you must consider the wavelength of the communications frequency you are using and the correction factor due to the difference in the physical and electrical length of the antenna. For frequencies between 3 and 50 MHz the correction factor is 0.95. Knowing this you can calculate the required length of your antenna using the following formula (for half-wave antennas):

$$\text{LENGTH (in meters)} = \frac{150 \times 0.95}{\text{Frequency in MHz}} = \frac{142.5}{\text{Frequency in MHz}}$$

$$\text{LENGTH (in feet)} = \frac{492 \times 0.95}{\text{Frequency in MHz}} = \frac{468}{\text{Frequency in MHz}}.$$

For quarter-wave antennas, the formula is the same, except that the constant is 234 instead of 468. Thus for a quarter-wave antenna, the length formula is:

$$\text{LENGTH (in feet)} = \frac{234}{\text{Frequency in MHz}}.$$

If you desire to construct a long-wire antenna (one wavelength or longer) then the following formula applies:

$$\text{LENGTH (in meters)} = \frac{150 \times (N - 0.05)}{\text{Frequency in MHz}}$$

$$\text{LENGTH (in feet)} = \frac{492 \times (N - 0.05)}{\text{Frequency in MHz}}.$$

Where N is the number of half-wavelengths in the total length of the antenna.

b. Omnidirectional Antennas. An omnidirectional antenna transmits the same power level in all directions. This is usually the simpler type of antenna and is much more common among tactical radio systems than the directional antenna. Because of this, it stands to reason that you can expect to experience more problems with the failure of an omnidirectional antenna than with a directional one. You will not normally fabricate a field-expedient omnidirectional antenna unless your current antenna breaks. The advantages of a field expedient omnidirectional antenna over the standard antenna provided with your radio set will generally be minimal. Tactical omnidirectional antennas are of two basic types: whip antennas and ground plane antennas.

The whip antenna is the simplest of the Marconi family of antennas. Theoretically, the whip antenna is an omnidirectional antenna. When attached to a vehicle, however, the radiation pattern shows a certain directionality depending on the placement of the antenna on the vehicle body. The whip antenna is the most portable type of antenna and, therefore, the most widely used in tactical radio communications. Because of the simplicity of its design, the whip antenna is also the easiest to fabricate a replacement for, should it break. The first step in fabricating a whip antenna is to cut a length of wire a quarter-wavelength long. Use the formulas you learned above to calculate the proper antenna length for your communications frequency. Next, using an insulator, attach one end of the antenna wire to a rope. Attach the free end of the antenna to your radio set (do not forget to ground your radio). Now all you have to do is hoist the end of the antenna attached to the rope so that the antenna is vertical and you

have your replacement. If trees are nearby, you can throw one end of your rope over a branch and hoist your antenna that way. You can also attach the rope to a long pole such as a broom handle and use that for an antenna mast.

If you take a whip antenna and add horizontal elements to the vertical radiator, the horizontal elements act as a ground reflector or counterpoise. This configuration is called a ground plane antenna. You can use a ground plane antenna on any type of soil because it creates its own reflection. In some configurations, you can tune the ground plane antenna to a certain frequency by changing the length of the radiating and reflecting elements. The broadband omnidirectional antenna system OE-254 is in common use today for VHF-FM tactical radio sets. It is an improvement over the earlier ground plane antennas because it does not have to be reconfigured physically when you change radio frequencies. The fact that the ground plane antenna has more parts also means that there are more parts to break. Radiating elements, reflecting elements, masts, guys, and insulators are all subject to damage in a real-world installation. The steps to fabricate a field expedient ground plane antenna vary depending on which portion of the antenna has been broken. If you are replacing a broken mast, for example, you can use a long wooden pole as you would for a whip. You can also attach the radiating element of the antenna to a rope using an insulator, and suspend the antenna from a tree or other tall object. This type of field expedient allows you to easily adjust the height of the antenna and also allows for quick setup and teardown.

You may occasionally find yourself in a situation where your whip antenna is not sufficient for your communication needs, and a more powerful antenna is necessary. In these situations you can fabricate a 292-type ground plane antenna out of antenna wire and other available materials. Using the formulas you have learned, calculate the length of wire required for a quarter-wavelength radiating element and three reflecting elements of the same length. Cut your antenna wire into these four sections. Cut three spacing sticks the same length. Connect the three spacing sticks to form a triangle and tie or tape the ends together. Attach an insulator to each corner of the triangle and attach one end of each reflecting element to each insulator.

Strip about three inches of insulation from the free end of each reflecting element wire and twist all three wires together. Attach the twisted ends of the reflecting elements to another insulator. Attach one end of the radiating element to the other side of this insulator, and connect the other end of the radiating element to a rope with an insulator (that's five insulators in all). Use the rope over a tree branch or other suitable object to suspend your antenna. Make the connection to your radio as short as possible; excess length reduces system efficiency. Connect the end of the radiating element that is attached to the insulator with the reflecting elements to the antenna terminal on your radio set using WD-1 field wire or an appropriate substitute. Connect the twisted ends of the reflecting elements to the case of your radio set, also using WD-1. Tape all your electrical connections. Your field-expedient ground plane antenna is now ready to operate. Remember that your antenna is tuned for a particular operating frequency. If you need to operate on a different frequency you should adjust the length of your antenna elements accordingly. Figure 1-2 illustrates an assembled field-expedient 292-type ground plane antenna.

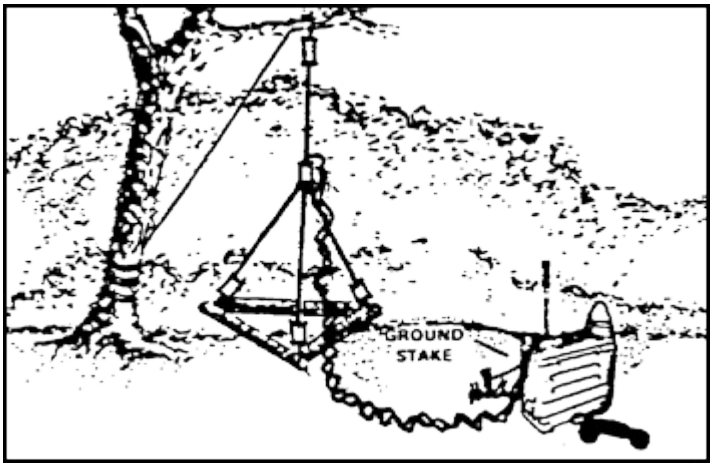

Figure 1-2. Field expedient ground plane antenna

c. Directional Antennas. While omnidirectional communications are good for communicating with mobile units, they do not provide very good communications security. Any station within range can pick up the signal transmitted from this type of antenna. Occasionally you may want to communicate with another station covertly. You will of course use coded transmissions, but even the fact that you are sending a signal out can give away your position if you are not careful. In this scenario the safest method of communications is to use a directional antenna. A directional can also provide the "extra punch" you might need in transmitting power to reach another station at the edge of your communications range. There are three basic types of directional antennas that you can easily employ in a field environment. They are the half-wave doublet, the long-wire antenna, and the vertical half-rhombic antenna.

The Hertz or half-wave antenna is a common configuration for field communications. This antenna is also called a center-fed doublet. You can orient the antenna either horizontally or vertically and the polarization of the antenna corresponds to the orientation. The antenna is directional, with the primary direction being perpendicular to the antenna axis. From this you can see that the Hertz antenna oriented vertically would be essentially omnidirectional. One drawback of the antenna is that it transmits perpendicular to its axis in all directions. For example, if you are transmitting a strong signal directly behind you to a rear element, you are also transmitting a strong signal directly in front of you to possible hostile forces. When you construct a Hertz antenna you must take care to construct it to the proper length for the frequency you are using. Do this using the formulas previously discussed for a half-wave antenna. The obvious disadvantage is that the antenna is tuned only for a small band of frequencies. Hertz antennas are very portable and are easy to set up and take down. You can also change the orientation of a Hertz antenna with minimum difficulty. Fabricating a field-expedient Hertz antenna is fairly simple. First cut your antenna wire to the proper half-wavelength length for your operating frequency and attach insulators to both ends. Cut the wire in half and connect the two pieces with a third insulator. Strip a small section of insulation from the wires where they connect to the center insulator. Using WD-1, attach one of the halves to your radio's antenna connection, and attach the other half to your radio's casing or other grounded point. For a horizontal half-wave doublet, the next step is to determine the correct azimuthal orientation for your antenna. You should set the antenna up perpendicular to the azimuth of the radio station you are trying to contact. Attach the insulators on the ends of the antenna to ropes and string the antenna between-two supports so that it is oriented properly.

For best results, the antenna lead going to the radio should be at right angles to the antenna for a length of at least six feet. For a vertical half-wave doublet, attach one end of the antenna to a rope and weight the other end with a rock or other heavy object. Alternately, you might want to tie the other end down to a stake or other fixed object. Since the vertical antenna transmits equally in all azimuthal directions, you do not need to worry about setting the antenna's orientation. Figures 1-3 and 1-4 show examples of field-expedient horizontal and vertical half-wave doublet antennas respectively.

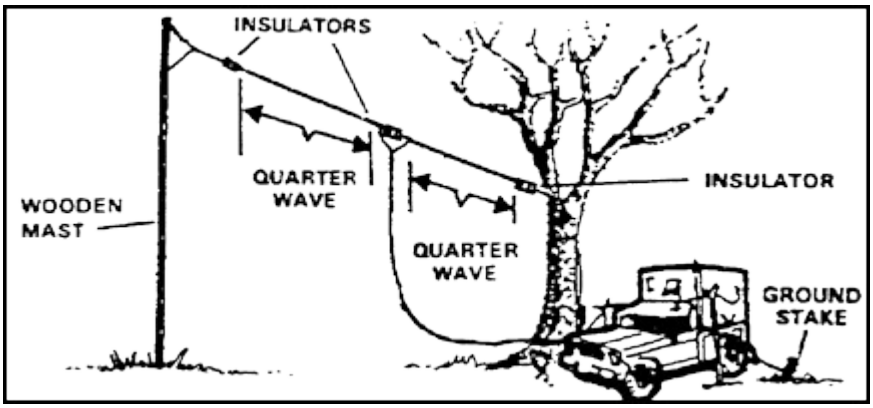

Figure 1-3. Field expedient horizontal half-wave doublet antenna

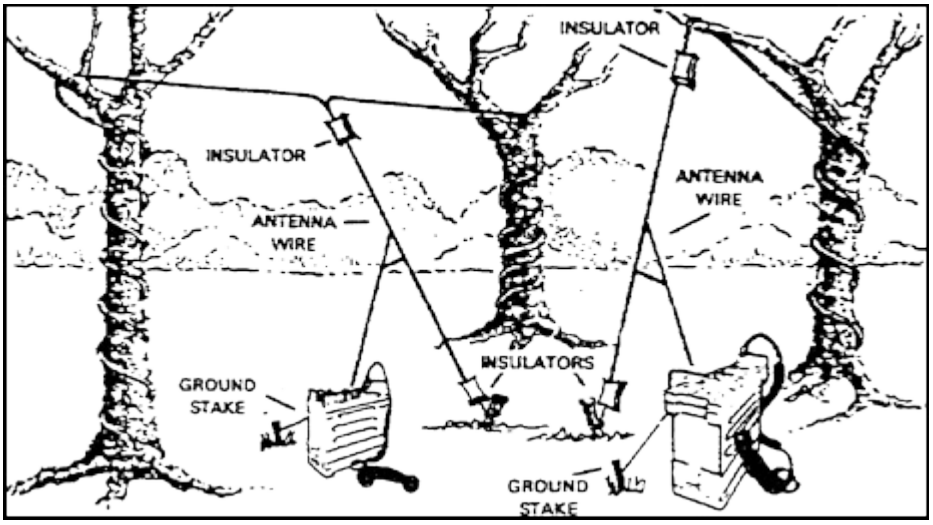

Figure 1-4. Field expedient vertical half-wave doublet antenna

The long-wire antenna is simply what the name implies. It is an antenna you have constructed to a certain number of wavelengths (using previous formula). You should calculate your antenna length so that it is at least two wavelengths long. Attach insulators to both ends of the antenna. To obtain directionality, you connect the radio set to one end and terminate the other end with a grounded resistor. You should always remember when choosing terminating resistors for any antenna that the rating of the resistor should be at least half of the rated output power of the radio set you are using. This will keep you from burning out the resistor. Once your long-wire antenna is configured, you orient it by pointing the terminated end toward the azimuth of the radio station with which you are communicating. You orient the antenna horizontally and as high off the ground as possible. The antenna will work as low as three feet from the ground, but efficiency will increase as it is raised. Figure 1-5 shows a long-wire

antenna with a terminating resistor. Without this resistor, the antenna will be bidirectional along its axis.

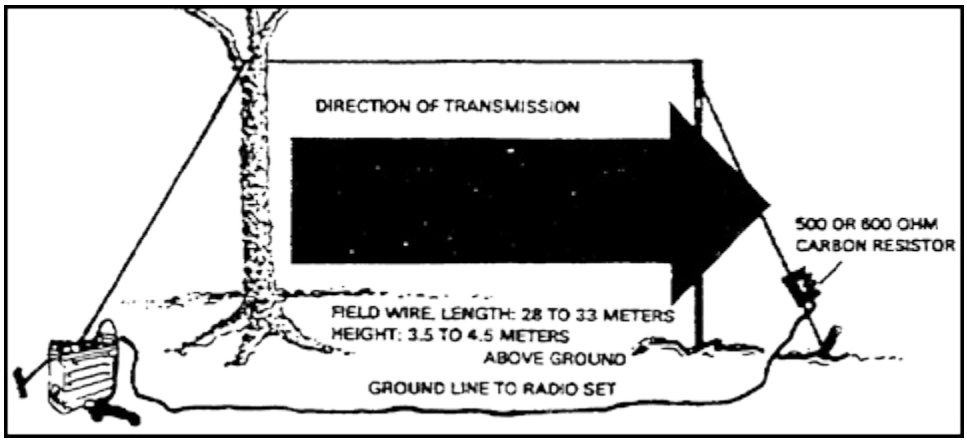
DIRECTION OF TRANSMISSION
500 OR 600 OHM
CARBON RESISTOR
FIELD WIRE, LENGTH: 28 TO 33 METERS
HEIGHT: 3.5 TO 4.5 METERS
ABOVE GROUND
GROUND LINE TO RADIO SET

Figure 1-5. Long-wire antenna with terminating resistor

The vertical half-rhombic antenna is a vertically-polarized directional antenna that operates between 30 and 88 MHz. It consists of two sloping segments, each about a wavelength long, and a horizontal segment that acts as a counterpoise. The antenna is easy to transport, set up, and tear down. You can also change the antenna azimuth quickly and easily. The use of the vertical half-rhombic antenna can not only provide directionality, but also provide extended range over the OE-254 antenna because it sends its energy out in only one direction. To construct a field-expedient half-rhombic antenna, calculate the length of wire (at least two wavelengths) for your operating frequency and cut your antenna wire to that length. Attach insulators-to both ends of the wire. Attach your radio's antenna lead to one end of the wire, and fasten the other end with a grounded terminating resistor as you did for the long-wire antenna above. Attach the middle of the antenna to a tall pole or tree, and stake the two ends to the ground. The pole or tree should be high enough so that the angle of the elements is approximately 54 degrees from vertical. You should orient the terminated end of your antenna along the azimuth of the radio station you are trying to talk to. For added efficiency string a length of WD-1 about a foot off the ground and attach it to the ground side of both ends of the antenna wire. Attach this wire to your radio casing. This added wire acts as a counterpoise and helps to reflect the portion of the signal that is transmitted toward the earth. A counterpoise is especially helpful in areas where the soil has very poor conductivity such as deserts, frozen ground, and extremely rocky terrain. Figure 1-6 illustrates a vertical half-rhombic antenna with a terminating resistor and a counterpoise.

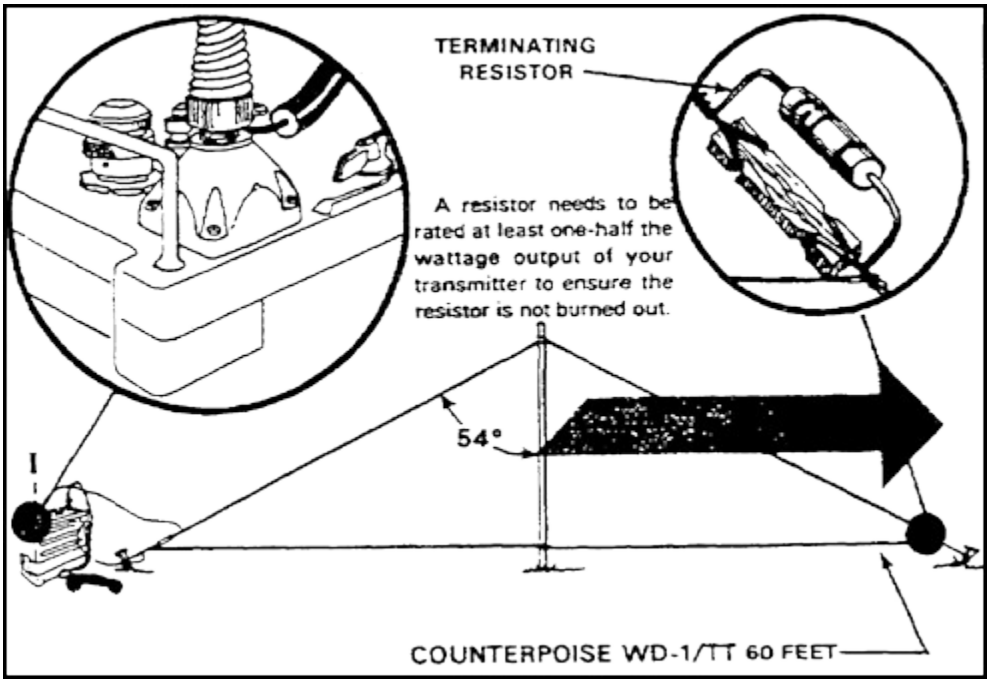
TERMINATING
RESISTOR
A resistor needs to be rated at least one-half the wattage output of your transmitter to ensure the resistor is not burned out.
54°
COUNTERPOISE WD-1/TT 60 FEET

Figure 1-6. Vertical half-rhombic antenna with terminating resistor and counterpoise

d. Tips on Selecting Field Expedient Antennas. Just as you are destined to have equipment failure, so are you destined to be in positions where communications is only marginal at best. This may be because of terrain obstructions, interference due to jamming or other RF noise, or even range limitations of your equipment. The following paragraphs provide some guidance on what to do when you find yourself in this situation.

Interference can be caused by many different things. Electronic jamming, industrial machinery, air traffic, other radio sets operating in your area, high tension lines, and even solar and cosmic disturbances can interfere with your radio communications. One way to compensate for this is by checking your radio system for any loose connections and by making sure your radio and antenna are properly tuned. Sometimes switching to another channel may help, but you may also lose communications with the station you are trying to communicate with.

If you can determine the source of the interference you may be able to use a directional antenna to eliminate some of it. This will only work, however, if the interference source and the station you are communicating with are on different azimuths.

Determining the source of interference may also tell you how the interfering signal is polarized. Most man-made RF noise is vertically polarized. Using a horizontally polarized antenna can do a lot to lessen the effect of interference. Likewise, in a forest vertically polarized waves tend to be absorbed by the trees more than horizontally polarized waves. RF interference caused by aircraft or commercial radio and television transmissions, on the other hand, is usually horizontally polarized. You should use a vertically polarized antenna if you are experiencing interference from one of these sources.

If you are having trouble communicating due to range fading, a directional antenna may help. It can boost your signal in the direction of the station you are talking to and will also increase your receiver sensitivity. If none of the previous measures improve your communications, you should also try

moving your antenna or raising or lowering your antenna. If you are still having trouble communicating there may be nothing to do but move to a different location and try again.

23. Summary.

In this lesson you have learned how the various tactical radio sets are used in communications systems. You have learned about point-to-point communications and retransmission stations. You have also learned how to fabricate several different field-expedient antennas to use in the field. In the next lesson you will learn about the command and control structure of the division from a communications standpoint, and how networks are set up to provide for the various aspects of operating the division in the battlefield.

Lesson 1: Employment of Tactical Radio Sets

Instructions The following items will test your understanding of the material covered in this lesson. There is only one correct answer for each item. When you have completed the exercise, check your answers with the answer key that follows. If you answer any item incorrectly, review that part of the lesson which contains the portion involved.

Situation: You are conducting a training session on tactical radio applications and field expedient antennas.

1. Which of the following SINCGARS configurations is a retransmission radio?

   - ○ A. AN/VRC-89.
   - ○ B. AN/VRC-90.
   - ○ C. AN/VRC-91.
   - ○ D. AN/VRC-92.

2. How can you make your field-expedient long wire antenna unidirectional?

   - ○ A. Add a counterpoise to the antenna.
   - ○ B. Add a terminating resistor to the free end.
   - ○ C. Add a terminating resistor to the radio end.
   - ○ D. Attach the free end of the antenna directly to ground.

3. Which of the following units is most likely to require a point-to-point communications system?

   - ○ A. A supply company making reports to headquarters.
   - ○ B. A rear element passing radio teletypewritten messages.
   - ○ C. An armored battalion commander making routine movement reports.
   - ○ D. A long-range surveillance company making time-critical intelligence reports.

4. You are constructing a long-wire antenna three wavelengths long to communicate on a channel frequency of 29.274 MHz. How long should you make your antenna?

   - ○ A. 50.0 feet.
   - ○ B. 50.4 feet.
   - ○ C. 100.0 feet.
   - ○ D. 100.8 feet.

5. You are using the AN/VRC-43 set to communicate with a special forces unit that is using the AN/PRC-70 set. The unit moves over a large hill, cutting off communications. Which of the following radio sets should you use to reestablish communications with the unit?

- A. AN/VRC-46.
- B. AN/GRC-106.
- C. AN/GRC-125.
- D. AN/GRC-160.

6. While the special forces unit is still on the other side of the large hill, it experiences a failure in its AN/PRC-70 set. Which of the following sets can the unit use to reestablish communications with you?

- A. AN/PRT-4A.
- B. AN/PRC-25.
- C. AN/PRC-74.
- D. AN/PRC-77.

7. You are directed to set up a net radio interface using your AN/VRC-12 series radio. Which of the following pieces of auxiliary equipment should you use to accomplish this?

- A. AN/GSA-7.
- B. AN/GRA-6.
- C. AN/GRC-19.
- D. AN/GRA-39B.

8. While you are in your exercise area, some civilian trucks with citizens' band radios enter your exercise area. Which radio set should you use to inform them that they are in a restricted area?

- A. AN/VRC-12.
- B. AN/PRC-25.
- C. AN/FRC-93.
- D. AN/GRC-160.

Lesson 1: Employment of Tactical Radio Sets

Situation: You are conducting a training session on tactical radio applications and field expedient antennas.

1. Which of the following SINCGARS configurations is a retransmission radio?

D. AN/VRC-92.

The AN/VRC-92 is the SINCGARS version of the retransmission configuration and is replacing the AN/VRC-45 and -49 retransmission sets.

2. How can you make your field-expedient long wire antenna unidirectional?

B. Add a terminating resistor to the free end.

Adding a terminating resistor to the free end of the antenna allows the antenna to resonate in one direction only and forces it to be unidirectional in the direction of the terminated end.

3. Which of the following units is most likely to require a point-to-point communications system?

D. A long-range surveillance company making time-critical intelligence reports.

Each of the other three units has a net that it makes normal reports on. Furthermore the information being passed by these units is not time critical. The surveillance company has to be able to pick up the radio and be in immediate contact with the command post. It is therefore the most likely unit to require a point-to-point communications system.

4. You are constructing a long-wire antenna three wavelengths long to communicate on a channel frequency of 29.274 MHz. How long should you make your antenna?

C. 100.0 feet.

Three wavelengths is six half-wavelengths. Using the formula for long-wire antennas gives:

LENGTH (in feet) =

$$\frac{492 \times (6 - 0.05)}{29.274\ \text{MHz}} = \frac{492 \times 5.95}{29.274\ \text{MHz}} = \frac{2927.4}{29.274\ \text{MHz}}$$

LENGTH = 100 feet.

5. You are using the AN/VRC-43 set to communicate with a special forces unit that is using the AN/PRC-70 set. The unit moves over a large hill, cutting off communications. Which of the following radio sets should you use to reestablish communications with the unit?

B. AN/GRC-106.

Since communications was cut off as the unit moved over the hill, you have an indication that the direct path of communication is no longer available. Most VHF communications take place along the direct path, so you must try another propagation path to communicate with the unit. The AN/GRC-106 is an HF radio, so it can use the sky-wave transmission path. The AN/PRC-70 has the capability to communicate in both HF and VHF bands and using both AM and FM modes. This feature makes it capable of taking advantage of whatever communications paths and equipment are available.

6. While the special forces unit is still on the other side of the large hill, it experiences a failure in its AN/PRC-70 set. Which of the following sets can the unit use to reestablish communications with you?

C. AN/PRC-74.

The unit is still out of the range of a VHF line-of-sight radio. If their AN/PRC-70 fails, they must use some other HF AM radio set. The AN/PRC-74 is the only choice that matches those criteria.

7. You are directed to set up a net radio interface using your AN/VRC-12 series radio. Which of the following pieces of auxiliary equipment should you use to accomplish this?

A. AN/GSA-7.

The unit is still out of the range of a VHF line-of-sight radio. If their AN/PRC-70 fails, they must use some other HF AM radio set. The AN/PRC-74 is the only choice that matches those criteria.

8. While you are in your exercise area, some civilian trucks with citizens' band radios enter your exercise area. Which radio set should you use to inform them that they are in a restricted area?

C. AN/FRC-93.

The AN/FRC-93 is a military derivative of the commercial citizens' band radio. The other choices are all VHF radios and would not be compatible with the truck's radios.

LESSON 2

DIVISION COMMUNICATIONS AND COMMAND AND CONTROL

CRITICAL TASKS: S1-5878.04-9001, 01-5704.04-9001, 01-5704.07-0001

OVERVIEW

LESSON DESCRIPTION:

In this lesson you will learn how division communications is structured for command and control including the types of radio networks used at the division level and the types of radios used in each network.

TERMINAL LEARNING OBJECTIVE:

ACTIONS:	a. Describe the basic structure of the division for command and control. b. Identify the different tactical radio nets, including mobile subscriber equipment (MSE) networks, and their purpose. c. Determine the tactical radio sets that would be assigned to each of the division nets.
CONDITION:	You will be given information from this lesson.
STANDARD:	To demonstrate competency of the terminal learning objective, you must achieve a minimum score of 70% on the subcourse examination.
REFERENCES:	The material contained in this lesson was derived from the following publications: FM 11-30, FM 11-32, FM 11-37, FM 11-50, and FM 24-1.

INTRODUCTION

You have learned about many different types of radios and antennas and you know how to take advantage of the various features of each of these devices. However, with all the different radio sets operating and all the different communications functions being performed, you can understand that control of communications is of paramount importance if information is to flow smoothly and reach the correct destination in a timely manner.

1. Division Command and Control Structure.

The Division commander is responsible for command and control (C2) of combat, combat support (CS), and combat service support (CSS) units. The medium by which he exercises this C2 function over the divisional area is radio. The command staff, especially the communications personnel, are vital to this function. The commander relies on his subordinate commanders and staff to supervise the wide range of C2 functions required to operate on the modern battlefield. The command staff perform their functions from command posts (CPs) dispersed throughout the division area. CPs are the nerve centers

of the division, and the effectiveness of the division as a whole depends directly on how well these CPs perform their functions. Scattering CPs throughout the division area also serves to decentralize the division C2 effort, making the division less vulnerable to a single assault or nuclear attack. The division CPs are further subdivided into three categories: Main CP, Tactical CP, and Division Rear CP/Division Support Command (DISCOM).

a. Division Main CP. If the multiple CPs are the nerve centers of the division, the division main CP is the brain. It is the division's permanent CP and is the clearing house for information in the division. The division main CP staff receives details of combat operations and threat activities and processes all this information to assist the division commander in making command decisions throughout the division. The division commander does not stay at the division main CP all the time, but divides his time between division main CP and division tactical CP. There are seven basic operations that are directed and coordinated from the division main CP. They are:

(1) Operations to disrupt and delay follow-on echelon forces.

(2) Interdiction.

(3) Divisional fire support.

(4) Electronic warfare (EW) operations.

(5) Suppression of threat air defenses.

(6) Mobility, countermobility, and survivability; and general engineering operations.

(7) Psychological operations.

The division signal officer or assistant division signal officer is located in the division main CP. He is responsible for ensuring proper and effective use of all communications assets.

He also serves as the division battle staff interface with the signal battalion and ensures that battle intelligence is evaluated for signal impact.

b. Division Tactical CP. The division tactical CP is a small, highly mobile package of selected personnel and equipment that provides C2 and communications well forward in the divisional area. This CP is primarily concerned with combat operations and is the location of the assistant division commander (maneuver)(ADC-(M)). The objective of the tactical CP is to place the ADC-M in the most effective position to maneuver the brigades and influence the battle. There is only one group of people comprising the tactical CP, but they maintain communications facilities at several different locations in order to accommodate displacements.

c. Division Rear CP/DISCOM. As you may have surmised, the division rear CP is located near the division rear elements. It performs most of the coordination of CSS for the division. The DISCOM may be collocated with the division rear CP or not, depending on available resources. The assistant division commander (support)(ADC-(S)) is responsible for coordinating the efforts of the division rear CP. There are six main operations that are directed from the division rear CP. They are:

(1) Administration and logistics.

(2) Civil affairs.

(3) Chaplain activities.

(4) Inspector general.

(5) Staff Judge Advocate.

(6) Division Headquarters, Headquarters Company maintenance, mess, and medical operations.

2. Division Radio Net Structure.

Single-channel net radios provide initial command, control, and communications at the division headquarters and throughout the division. Figure 2-1 shows the overall division radio net structure. The basic single-channel radio nets are the command and operations net, the intelligence net, the administrative and logistical net, the fire direction net, the surveillance net, the rear operations net, the HF voice net, and the general purpose (GP) RATT net.

NET STATIONS	DIV CMD OPN FM NET	DIV INTEL FM NET	DIV REAR OPN CEN FM NET	DIV HF VOICE	DIV GP RATT NET
DIV CDR	*				
ASST DIV CDR	*				
DIV OPN CELL (G3)	*	*	*	*	*
DIV INTEL CELL (G2)	*	*		*	
OPN FWD (TAC CP)	*			*	
INTEL FWD		*			
DIV SPT CMD	*	*	*	*	*
BDE CP	*	*			
BDE TRAINS	*		*		*
RECON BN	*	*	*	*	*
AB	*	*		* *	*
ENGR BN	*	*	*	*	
MI BN		*			*
ADA BN	*	*		*	*
DIVARTY	*	*	*	*	*
MP CO	*		*		
REAR OPN CEN	*		*	*	
SIG BN	*		*		
LX TM LIAISON TEAM	*				
LONG-RANGE RECON UNIT		*			

Figure 2-1. Standard division radio net structure

a. Command and Operations Net. The command and operations net has the highest priority of all division radio nets. It is used to pass orders and operational information. The division commander and ADCs use this net for tactical control, combat coordination, and tactical data reporting.

b. Intelligence Net. The intelligence net is the primary backup for the command and operations net and has the second highest priority in the division. It is used to pass intelligence information and spot reports.

c. HF Voice Net. The HF voice net is used as the primary backup to the intelligence net and as the secondary backup to the command and operations net.

d. Fire Direction Net. The fire direction net is primarily a data net and is used to exchange technical and firing data among artillery units.

e. Surveillance Net. The surveillance net is established by the battalion battlefield information control center to coordinate and control ground surveillance radar and unattended ground sensor teams. It is used to pass reports dealing with threat movements and massing.

f. Administrative and Logistical Net. The administrative and logistical net is used to pass personnel and supply traffic. Because this information is not generally of the same gravity as the information on the command and operations and intelligence nets, the administrative and logistical net has a lower priority.

g. Rear Battle Net. The rear battle net is controlled from the division rear CP. It is used to control rear operations. At the division level, this is a separate net. At the brigade level and below, the rear battle net is merged with the command and operations net.

h. GP RATT Net. The GP RATT net passes hard copy radio teletype traffic between the various division headquarters elements. Because of the time-late nature of RATT traffic, this net is not used to pass lengthy or time sensitive information.

3. Combat Net Radio.

The new radio systems being brought into use demand a new structure for communications. The combat net radio (CNR) network was designed to integrate and take full advantage of the enhancements in modern radio technology in support of C2. The CNR net is based around three basic radio systems, each with its own distinctive capabilities and characteristics. The three systems are: improved high frequency radio, single-channel ground and airborne radio system, and single-channel tactical satellite (TACSAT).

a. The Role of CNR. The primary role of the CNR network is voice communications for C2. It also performs a secondary role as a backup for data transmission when requirements exceed the capacity of the Army data distribution system or mobile subscriber equipment services. In CNR networks, voice C2 information has priority except when SINCGARS is used with the tactical fire direction system or advanced field artillery tactical data system.

b. CNR Network Structure. The CNR system generally establishes three categories of VHF-FM networks. They are C2, administrative/logistics, and intelligence. The C2 network (the primary CNR net) is subdivided into functional areas of maneuver, fire support, aviation, air defense artillery (ADA), and engineers. Figure 2-2 shows the typical network structure for the division or brigade level. These nets serve the same functions as their counterparts in the divisional tactical radio network structure and can generally interface with the equipment in those nets.

4. Mobile Subscriber Equipment.

MSE was purchased by the Army to meet the evolving needs of the modern battlefield. It is a largely automatic network system that provides highly mobile, highly decentralized communications from the corps level down. MSE takes advantage of modern computer and other electronic technology; newer, more compact equipment; and ultra high frequency (UHF), VHF, and super high frequency (SHF) frequency management to provide a network system that will allow any subscriber in the corps to communicate with any other subscriber by simply dialing a telephone number.

The MSE system is composed of branching layers of equipment that evolve a few central processing areas into a network capable of providing communications to over 10,000 subscribers. The system control centers (SCCs) are the central points from which the entire MSE system is controlled. The hubs of the MSE system are called node centers (NCs). All NCs are interconnected and communicate with each other. SCCs are responsible for NC operation. NCs are mobile equipment stations and deploy with the division units to ensure that the entire battlefield area is covered. Each NC covers a certain geographical area based on the terrain and its placement and transmitting range. Each NC has several extension nodes branching from it. They are either large extension nodes (LENs) or small extension nodes (SENs). LENs and SENs provide voice, data, and facsimile communications to the division CPs via wire service, and provide automatic switching to all MSE subscribers. NCs, LENs, and SENs are all connected by UHF links. To provide access to mobile subscribers, LENs and SENs are also linked to remote access units (RAUs).

NET STATIONS	CMD OP FM NET	INTEL FM NET	REAR OP CEN FM NET	OP HF VOICE NET (IHFR)
CDR	*	*		
ASST CDR	*	*		
OP G3 S3	**	*	*	**
G2 S2		**		
TAC G3 S3	*			*
TAC G2 S2		*		
DISCOM	*		**	
SUBORD CP	*	*	*	*
MSB/FSB				
AVN UNITS	*	*	*	*
ENGR UNIT	*	*	*	*
MI UNIT	*	*		*
ADA UNIT	*	*		*
ARTY	*	*	*	*
MP	*		*	
REAR OP CEN	*		*	*
SIG	*	*	*	
LO	*			
LONG-RANGE RECON DET		*		

*NET MEMBER

**NCS

Figure 2-2. Typical CNR network structure for division or brigade level

RAUs are essentially radio transmission sites that receive traffic from one subscriber and route it to the proper destination. RAUs are placed so that their areas of coverage overlap slightly. Thus a subscriber travelling from one RAU's area to another does not have to reestablish communications. The mobile subscriber radiotelephone terminal (MSRT) in the subscriber's vehicle automatically searches for the nearest RAU's beacon signal and shifts communications to that RAU. From this you can see that the MSE system can provide reliable communications even if a large portion of the system is overrun and destroyed. Because of the automatic frequency management and routing features of MSE, a subscriber has only to know the phone number of the party he wishes to speak to in order to communicate with that party. Figure 2-3 illustrates the branching architecture of the MSE system.

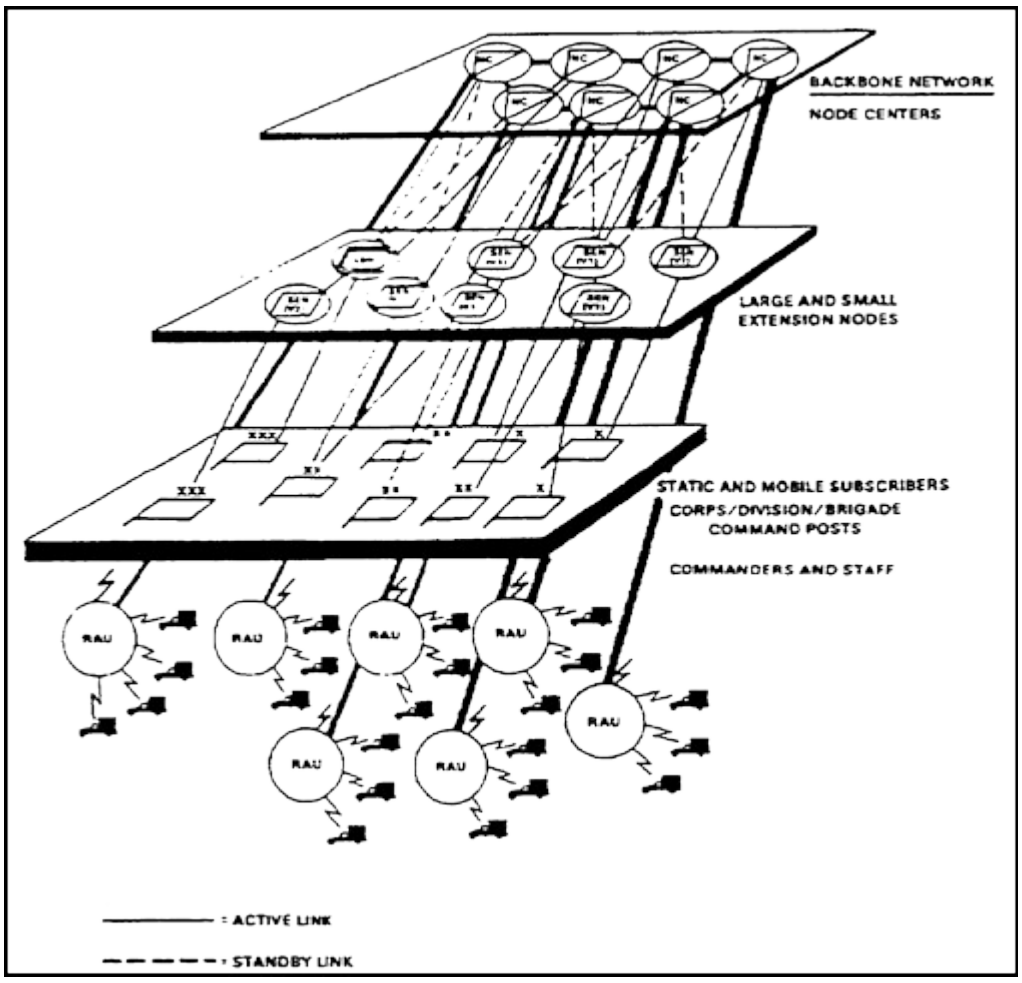

Figure 2-3. Branching architecture of MSE system

MSE does not replace the data distribution or CNR systems described above as it provides very limited support for corps and division deep operations. Its main contribution is to corps and division close and rear operations. With advice from the signal staff, the commander is responsible for using communications systems to best support his units. This support maximizes the units' chances for mission success.

5. Tactical Radio Sets.

You have already learned about the division network structure for tactical radio communications. With the advent of CNR, the network structure is essentially the same, but the equipment being used to effect

communications is changing. Different tactical radio sets function better at different levels in the command hierarchy. The impact to you as a signal officer is that you must be aware of the equipment used by different units so that you can maintain communications with them on an ongoing basis. If the division was a homogeneous unit that all used the exact same radio configuration, your job would be simple. Your division may in fact be composed of units with a wide variety of equipment. You may need to communicate with units equipped with SINCGARS equipment or units equipped with the very oldest single-channel gear. You need to know what type of equipment to expect for a given unit type so that you can use the appropriate equipment configuration to communicate with that unit.

a. Squad Applications. The squad is the smallest communications unit and the equipment used at this level is mostly low powered. The AN/PRT-4A and AN/PRR-9 are the main means of internal communication. For a squad using SINCGARS, the AN/PRC-119 is the radio you will most likely find. These units will generally operate on low power and be used for short-range communications only.

b. Company Applications. At the company level, the range of equipment broadens, and you may find quite a variety of different configurations. The size of the unit indicates that the range of communications is still short to medium, but wider than the range of squad-level communications. Tactical radios you will likely encounter include the AN/PRC-25 and PRC-77 series in their manpack and vehicular configurations. For companies equipped with SINCGARS you will find the AN/PRC-119 again, and also the short-range vehicular configurations of AN/VRC-87 and VRC-88 .

c. Battalion and Higher Applications. The battalion and above levels expand both the communications range and the range of equipment used. You will need to communicate with all variations of the AN/VRC-12 series of radios as well as the whole range of SINCGARS radios. The battalion and division will also use RATT systems (for the GP RATT net) based on either the AN/GRC-19 or -106 AM radios. Here the type of radio really becomes critical as not all sets will net together. At this level you will also have need of the newer IHFR radios for long-range communications with special forces and surveillance units that are out of LOS range required for FM radios. These radios include the AN/PRC-104, the AN/GRC-213, and AN/GRC-193 IHFR sets. Special forces units may also use the AN/PRC-70 series if they have not yet been updated to IHFR equipment.

6. Summary.

In this lesson you have learned about the communications and C2 structure of the division. You have learned about the tactical radio nets employed by the division and what type of equipment you might find in each of the different nets. The next lesson will teach you the basics of another communications system, the net radio interface.

Lesson 2: Division Communications and Command and Control

Instructions The following items will test your understanding of the material covered in this lesson. There is only one correct answer for each item. When you have completed the exercise, check your answers with the answer key that follows. If you answer any item incorrectly, review that part of the lesson which contains the portion involved.

Situation: You are the division assistant communications officer.

1. Psychological operations are handled from which of the following command posts?

   - ○ A. DISCOM.
   - ○ B. Division rear CP.
   - ○ C. Division main CP.
   - ○ D. Division tactical CP.

2. Which of the division communications nets should you use to pass routine hardcopy reports?

   - ○ A. The GP RATT net.
   - ○ B. The fire direction net.
   - ○ C. The division HF voice net.
   - ○ D. The command and operations net.

3. What portion of the MSE system allows the use of MSRTs?

   - ○ A. The NCs.
   - ○ B. The LENs.
   - ○ C. The SENs.
   - ○ D. The RAUs.

4. Which of the following SINCGARS units would you most likely find at the company level?

   - ○ A. AN/VRC-87.
   - ○ B. AN/VRC-90.
   - ○ C. AN/VRC-91.
   - ○ D. AN/VRC-92.

5. What is the primary role of the combat net radio network?

- ○ A. Voice transmission for Intelligence Systems.
- ○ B. Data transmission for Logistics Control Systems.
- ○ C. Data transmission for Command and Control Systems.
- ○ D. Voice transmission for Command and Control Systems.

Practice Exercise Answer Key & Review
Lesson 2: Division Communications and Command and Control

Situation: You are the division assistant communications officer.

1. Psychological operations are handled from which of the following command posts?

   C. Division main CP.

   Psychological operations are conducted from the division main CP. The tactical CP is involved in the movement and employment of forces, and the rear CP and DISCOM are involved in support operations.

2. Which of the division communications nets should you use to pass routine hardcopy reports?

   A. The GP RATT net.

   The GP RATT net is a radio teletypewriter net. As such it is the net you should use to pass hardcopy information.

3. What portion of the MSE system allows the use of MSRTs?

   D. The RAUs.

   The radio access unit provides radio coverage for the battlefield so that the mobile users can access the MSE system using MSRTs installed in their vehicles.

4. Which of the following SINCGARS units would you most likely find at the company level?

   A. AN/VRC-87.

   The AN/VRC-87 is a short-range vehicular configuration of the SINCGARS radio set. Each of the other configurations is a long-range set and would more likely be found at the battalion level or above.

5. What is the primary role of the combat net radio network?

D. Voice transmission for Command and Control Systems.

The CNR system was designed to integrate new technologies into a system to provide voice communications for command and control operations. CNR also serves other functions, but this is the primary one.

LESSON 3

NET RADIO INTERFACE OPERATION

CRITICAL TASKS: S1-5878.04-9001, 01-5704.04-9001, 01-5704.07-0001

OVERVIEW

LESSON DESCRIPTION:

In this lesson you will learn the definition of NRI systems. You will learn how these systems are placed in the division and how they are established. You also learn the procedures for operating an NRI station and what equipment is used to establish them.

TERMINAL LEARNING OBJECTIVE:

ACTIONS:	a. Define the need for net radio interface in a tactical environment.
	b. Describe the equipments and their function at an NRI station.
	c. Describe the basic procedures used to process an NRI call.
CONDITION:	You will be given information from this lesson.
STANDARD:	To demonstrate competency of the terminal learning objective, you must achieve a minimum score of 70% on the subcourse examination.
REFERENCES:	The material contained in this lesson was derived from the following publications: FM 11-37, FM 11-50, and FM 24-18.

INTRODUCTION

You have already learned how the commander uses the wide variety of tactical radios and telephone systems available to him to command and control his unit's operations in the modern battlefield. Sometimes, however, he may have need of both telephone and radio systems simultaneously. Thus he has need of some method of interconnecting tactical radios with wire telephone systems. The NRI system provides this interface. Figure 3-1 illustrates a basic NRI system.

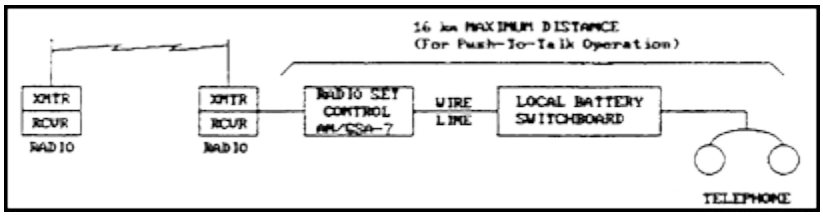

Figure 3-1. Basic NRI system

1. Establishment of NRI.

NRI is established and maintained by the division signal battalion. NRI stations may be set up wherever they are required, but the signal battalion establishes certain NRI stations as a matter of routine. At the division level, these stations are located at:

a. Division main CP.

b. Division support command.

c. Division area signal centers (ASCs).

d. Division artillery.

The operator of the NRI system is responsible for maintaining both the radio and wire portions of the system in working order. His responsibility does not stop at the facility. He must also be able to locate problems at their source and quickly correct them even if they are not in the actual NRI facility itself. Because of this, the NRI operator must be familiar with the operation of the telephone switchboard and the radio site as well as the NRI facility.

2. Uses of NRI.

Just as the name implies, NRI is a set of equipment and procedures that provides an interface between wire telephone networks and tactical radio systems by connecting a radio transmitter to the telephone system at one end of the communications chain and connecting a radio receiver to the telephone network at the other end. An obvious advantage is that unit commanders can communicate with their units via wire telephone even when they are mobile. Some other uses of NRI (at the division level) are:

a. To establish emergency communications between mobile FM radio stations and elements connected to the division area telephone system by telephone.

b. To establish communications between FM radio stations separated by distances that are beyond the direct operating range of their FM radio sets.

c. By the commanding general, division staff, and other designated key personnel in the division when operating from a mobile CP to contact division elements connected to the division area communications system.

d. For initial establishment of telephone service from the division area communications system to using units.

e. For voice communications between mobile combat elements in the division forward area and supporting division logistics elements in the rear.

f. For communications between low-flying Army aircraft operating in distant parts of the division area and airstrips of flight control elements connected to the division area communications system, when directed FM radio cannot be maintained.

g. For communications between forward air controllers and the air liaison officer's communications facilities when these facilities are connected with the division area communications system.

h. To keep commanders and staffs in contact with subordinate and higher headquarters, as required, during displacement of CPs.

i. To connect two switchboards and to span a break in a wire line between units.

j. For communications during river crossings.

3. NRI Equipment.

The equipment used for NRI varies according to the mission of the unit using NRI. The type of radio and telephone system employed also dictates the type of NRI equipment. With the advent of SINCGARS and MSE, the different types of NRIs available have expanded. Standard NRIs will connect the regular two-wire telephone service and either the AN/VRC-12 series radios or SINCGARS equipment. You can also establish NRIs between SINCGARS and MSE equipment. The following paragraphs will introduce you to some of the equipment used for an NRI.

a. AN/GSA-7. The AN/GSA-7 is the main component used to provide NRI services. It is a small remote switching device that can control the AN/VRC-12 series radios remotely at distances of up to 16 km (10 miles). The circuitry in the GSA-7 allows the operator to connect the two-wire telephone system and the four-wire push-to-talk FM radio system. It automatically converts the radio signal to a telephone format and vice versa. The GSA-7 also converts the 20 Hz telephone ring signal to a 1600 Hz radio attention tone so that the operator will be aware of incoming calls. You do not have to use proper radio communications procedures when you are talking on a regular phone system. Once the phone system is connected to the radio system, however, anyone using the interface must observe strict radio communications procedures regardless of which portion of the system he is using. To remind the users of this, the GSA-7 produces a 2000 Hz beep tone when it is keyed by the remote telephone operator. The operator can hear this tone at five second intervals while he is talking. This is to remind him of the need to use proper radio procedures. The GSA-7 can be mounted in a vehicle or installed in a fixed location. Figure 3-2 shows the front of the AN/GSA-7.

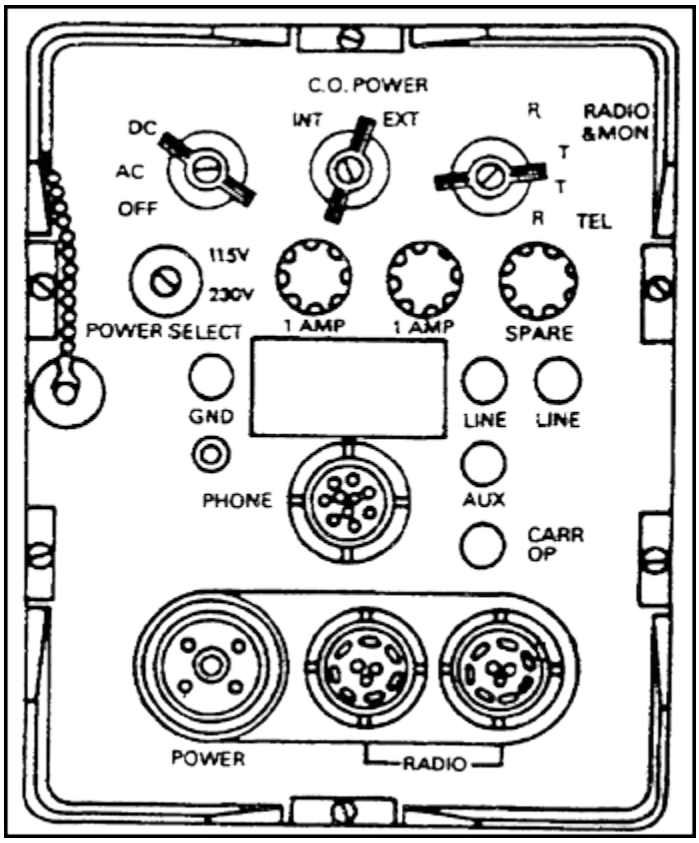

Figure 3-2. Front of AN/GSA-7

b. AN/GRA-39. If you do not have an AN/GSA-7 unit, or if your unit malfunctions, you can use the AN/GRA-39 as a substitute for it. The GRA-39 is a bit more limited than the GSA-7. It can only control the radio set remotely from up to 3.2 km (2 miles) away. It will, however, provide the NRI interface and allow you to continue your NRI operations. The GRA-39 consists of two units; the C-2329/GR, used at the radio site, and the C-2328/GR, used at the remote site.

c. Telephone Switchboards. You can use a wide variety of telephone switchboards to provide NRI services. Manual switchboards SB-22/PT, SB-86/P, and SB-3082/GT; and manual switchboard configurations AN/MTC-1, AN/MTC-3, AN/MTC-7, AN/MGC-9, AN/TTC-35, AN/TTC-23, and AN/TTC-29. The automatic switchboard AN/TTC-38 will also interface with NRI equipment. The basic connection for the NRI system is to connect the switchboard to the two LINE terminals on the GSA-7.

d. Auxiliary Equipment. Establishing an NRI station requires a few pieces of auxiliary equipment not yet mentioned. If you are using the GSA-7, you will also need a portable telephone set TA-312/PT, a cable assembly CX-7474, and an installation kit. If you are using a GRA-39 to provide NRI you will need a switchboard SB-22/PT (if that is not the primary switchboard you are using) to provide the interface between the GRA-39 and your primary switchboard. The GRA-39 also uses the CX-7474 cable assembly. You also require a radio set to complete the opposite end of the NRI system. Figure 3-3 shows the connections for an NRI system using the AN/GSA-7 and the AN/VRC-49 radio set.

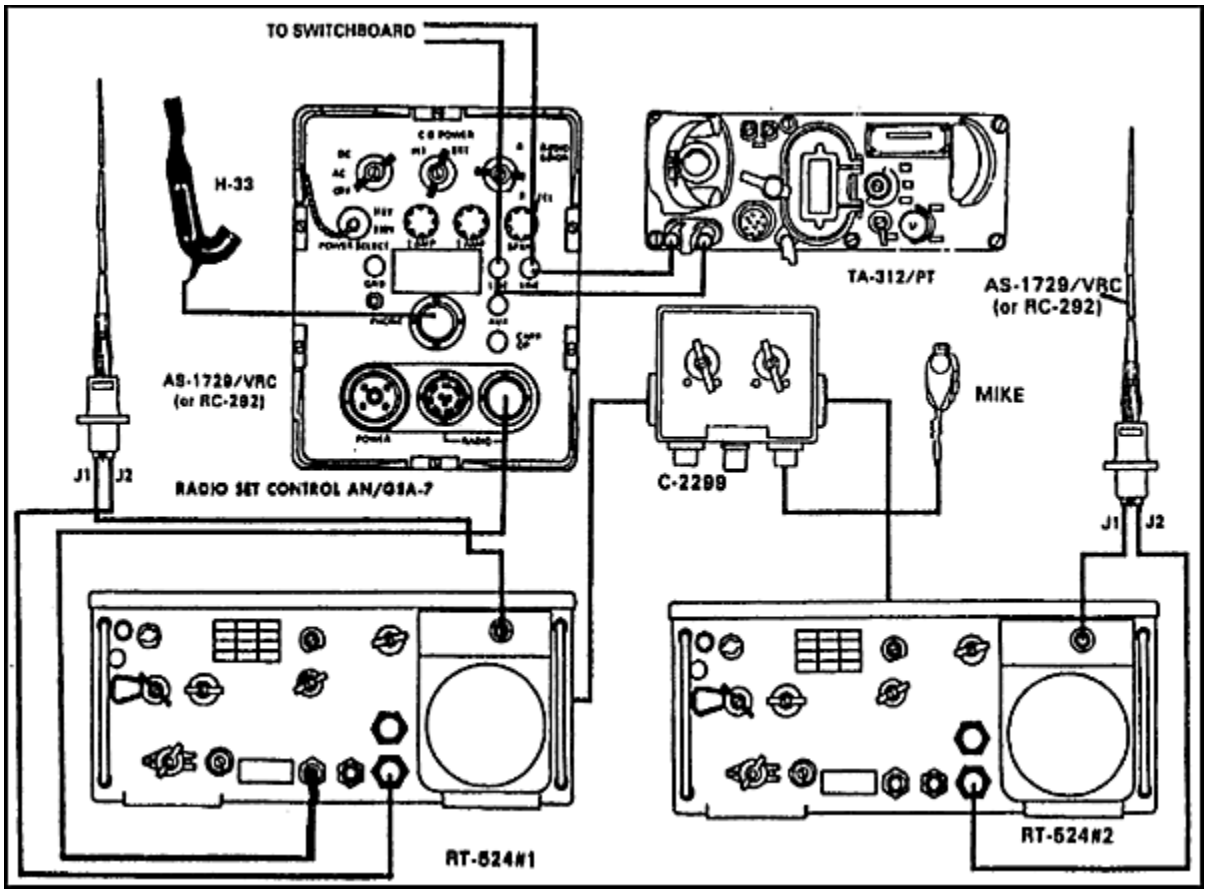

Figure 3-3. Connections for NRI system using AN/GSA-7 and AN/VRC-49 radio sets

e. Security Equipment. Since you can use NRI to pass important information, it is desirable to provide communications security for the NRI system. The VINSON and NESTOR secure devices are both compatible with NRI equipment. The principal difference is that the VINSON device (KY-57) can provide security for all portions of the NRI system while the NESTOR device (KY-38) will only provide secure radio. Thus if you use NESTOR to secure your NRI system you must ensure that the wire portions of your system are in a secure area and not subject to being tapped.

4. NRI Procedures.

Because NRI connects two different communications systems with different communications procedures, it is logical that a procedure should be established for communicating on an NRI network. Regular wire telephone system communications procedures are substantially less formal than radio procedures.

Since the NRI system provides access to both, any party using NRI should always observe formal radio communications procedures. This includes the correct use of call signs, procedure words, and authentication procedures. The call procedure is essentially the same for any NRI equipment. The connection procedures may change depending on what type of NRI equipment you are using.

a. Call Originating from a Telephone Subscriber. When a telephone subscriber desires to make an NRI call, he must first contact his switchboard operator unless he can call the NRI operator directly. This depends on the type of switchboard used to provide the NRI interface. If the subscriber contacts the switchboard operator first, he will request to be connected to the NRI operator. Once he has contacted the NRI operator, the subscriber identifies his station and tells the NRI operator what radio station he wishes to contact. The NRI operator then looks up the call sign for the subscriber and the radio station he is contacting and contacts the radio station using his radio set. He contacts the desired station's radio net and requests permission to enter it. Since he is a new station entering a net, both he and the net control station (NCS) for the net he is contacting must authenticate. Once the NRI operator has entered the net, he contacts the desired radio station and informs the operator that there is an NRI call for him. He then tells the telephone subscriber that he has contacted the desired party. He also informs the subscriber of his call sign (since the subscriber does not have a communications-electronics operation instruction (CEOI)) and of the call sign of the radio station, and admonishes the subscriber to use proper radio procedures. He then tells the subscriber what level of security is on the line and tells him to proceed with his call. If the NRI interface is provided by the GSA-7, a beep tone will continually remind the telephone subscriber that he is talking on a radio net and should use proper radio procedures.

b. Call Originating from a Radio Station. When a radio station operator desires to place an NRI call, the first thing he must do is contact the NRI operator. He may have to leave his net if the NRI frequency is different from his own. Once he has contacted the NRI operator, he requests the call sign of the party he wants to communicate with. The NRI operator looks up the station designation of the telephone subscriber and contacts the subscriber directly or through the switchboard operator. As with the previous example, once the NRI operator has contacted the telephone subscriber, he informs the subscriber that there is a radio call for him. He gives the subscriber the necessary call sign information and again admonishes the subscriber to use proper radio procedures. He then contacts the radio station

operator and tells him to proceed with his call. Appendix B contains an extract from FM 24-18 that illustrates the procedure of placing an NRI call from both the subscriber and radio operator ends using the AN/GSA-7.

5. Radio Set Control C-6709/G.

The radio control set C-6709/G is a modern radio control set which will replace the AN/GSA-7 and AN/GRA-39 for NRI services with an automatic switchboard. It can control a radio set from a distance of up to 2.5 miles (4 km). It is equipped with circuits to automatically process NRI calls so that the operator does not have to be so involved in the call process. With the AN/VRC-12 series radios, the C-6709/G is compatible with both the VINSON and NESTOR devices. The C-6709/G is also used to provide NRI between CNR radios and the MSE telephone system. When it is used in this application, the KY-90 security device is used to provide secure communications. The procedure for placing NRI calls with the C-6709/G is similar to that for the AN/GSA-7 and AN/GRA-39. Appendix B provides an extract from FM 24-18 that illustrates this procedure and the operation of the C-6709/G unit itself. You should review this information now.

6. Summary.

In this lesson you have learned about the NRI system, including its uses and equipment used to provide it. You have also learned how to place an NRI call as a telephone subscriber or as a radio station operator. Now use this information to complete the following practice exercise.

Lesson 3: Net Radio Interface Operation

Instructions The following items will test your understanding of the material covered in this lesson. There is only one correct answer for each item. When you have completed the exercise, check your answers with the answer key that follows. If you answer any item incorrectly, review that part of the lesson which contains the portion involved.

Situation: You are the signal officer in charge of NRI for your division.

1. Which of the following devices is NOT used to provide NRI services?

   - ○ A. AN/GSA-7.
   - ○ B. AN/GRA-39.
   - ○ C. C-6709/G.
   - ○ D. C-2299/VRC.

2. For which of the following interfaces should you establish a net radio interface?

   - ○ A. Netting an IHFR radio with a RATT network.
   - ○ B. Connecting a SINCGARS radio with an MSE network.
   - ○ C. Connecting a wire telephone system to an MSE network.
   - ○ D. Netting a SINCGARS radio with an AN/VRC-12 series radio.

3. When you establish an NRI using the AN/GSA-7 what is the purpose of the 2000 Hz beep tone?

   - ○ A. To remind the telephone subscriber to use proper radio procedures.
   - ○ B. To alert the NRI operator that there is an incoming radio call.
   - ○ C. To let the radio operator know that the NRI is operating properly.
   - ○ D. To alert the NRI operator that there is a wire telephone call.

4. Using the C-6709 device, from how far away can you control the radio transmitter?

   - ○ A. 2.0 miles.
   - ○ B. 2.5 miles.
   - ○ C. 5.0 miles.
   - ○ D. 10.0 miles.

Practice Exercise Answer Key & Review
Lesson 3: Net Radio Interface Operation

Situation: You are the signal officer in charge of NRI for your division.

1. Which of the following devices is NOT used to provide NRI services?

   D. C-2299/VRC.

   The AN/GSA-7, AN/GRA-39, and C-6709/G are all devices that will provide NRI services. The C-2299/VRC is a radio set control used to provide retransmission functions in the AN/VRC-12 series radios.

2. For which of the following interfaces should you establish a net radio interface?

   B. Connecting a SINCGARS radio with an MSE network.

   All other choices involve connecting a wire system with another wire system, or connecting a radio set with another radio set or network. SINCGARS to MSE is the only choice that combines a radio set and a telephone system.

3. When you establish an NRI using the AN/GSA-7 what is the purpose of the 2000 Hz beep tone?

   A. To remind the telephone subscriber to use proper radio procedures.

   The AN/GSA-7 produces a 2000 Hz beep tone that sounds every five seconds when the transmitter is keyed. This tone serves as a reminder to the subscriber that he is transmitting on a radio frequency and that he should observe proper radio procedures.

4. Using the C-6709 device, from how far away can you control the radio transmitter?

   B. 2.5 miles.

   The C-6709/G can control a radio transmitter from a distance of up to 2.5 miles or 4 km.

APPENDIX A - LIST OF ACRONYMS

ACCP	Army Correspondence Course Program.
ADA	Air Defense Artillery.
ADC-(M)	Assistant Division Commander (Maneuver).
ADC-(S)	Assistant Division Commander (Support).
AM	Amplitude Modulation.
APC	Armored Personnel Carrier.
ASC	Area Signal Center.
C2	Command and Control.
CEOI	Communications-Electronics Operation Instruction.
CNR	Combat Net Radio.
CP	Command Post.
CS	Combat Support.
CSS	Combat Support Service.
CW	Continuous Wave.
DISCOM	Division Support Command.
DSB	Double Sideband.
EW	Electronic Warfare.
FH	Frequency Hopping.
FM	Field Manual or Frequency Modulation.
FSK	Frequency-Shift Keying.
GP	General Purpose.
HF	High Frequency.
Hz	Hertz.
ICOM	Integrated Communications Security.
IHFR	Improved High Frequency Radio.

IVRCU	Intravehicular Control Unit.
KEK	Key Encryption Key.
kHz	Kilohertz.
km	Kilometer.
LEN	Large Extension Node.
LOS	Line of Sight.
LSB	Lower Sideband.
MHz	Megahertz.
mi	Mile.
MSE	Mobile Subscriber Equipment.
MSRT	Mobile Subscriber Radiotelephone Terminal.
NC	Node Center.
NCS	Net Control Station.
NRI	Net Radio Interface.
RATT	Radio Teletypewriter.
RAU	Remote Access Unit.
RF	Radio Frequency.
RT	Receive-Transmitter.
SCC	System Control Center.
SEN	Small Extension Node.
SHF	Super High Frequency.
SINCGARS	Single-Channel Ground and Airborne Radio System.
SRCU	SINCGARS Remote Control Unit.
SSB	Single Sideband.
TACSAT	Tactical Satellite.
TEK	Traffic Encryption Key.

TSK	Transmission Security Key.
UHF	Ultra High Frequency.
USB	Upper Sideband.
VHF	Very High Frequency.

APPENDIX B - PUBLICATION EXTRACTS

FM 11-32, October 1990.
FM 24-18, September 1987.
TC 24-24, October 1988.

Use the above publication extract to take this subcourse. At the time we wrote this subcourse, this was the current publication. In your own work situation, always refer to the latest official publication.

Field Manual
No. 24-18

*FM 24-18
HEADQUARTERS
DEPARTMENT OF THE ARMY
Washington, DC, 30 September 1987

Tactical Single-Channel Radio Communications Techniques

PREFACE

Purpose and Scope

This manual provides information and guidance to all personnel who are involved with and use single-channel radio in tactical situations.

To ensure your understanding of all the material presented, this manual includes a brief discussion of radio fundamentals, antennas, and radio-wave propagation. It also covers procedures and techniques that have been used effectively during tactical operations to include: site selection and reliability factors; operation in the several transmission modes and under unusual conditions; field expedients; electronic warfare techniques and reporting; and other aspects of the practical applications of single-channel radio. There are other items pertinent to single-channel radio operations listed in the appendixes.

User Information

The proponent of this publication is HQ TRADOC. You are encouraged to submit comments and recommended changes to improve this manual. Submit you comments on DA Form 2028 (Recommended Changes to Publications and Blank Forms) and key them to the pages, paragraphs, and lines of text to which they apply. If DA Form 2028 is not available, a letter is acceptable. Provide reasons for your comments to ensure complete understanding and proper evaluation. Forward your comments to the Commander, United States Army Signal Center and Fort Gordon, ATTN: ATZH-DTL, Fort Gordon, Georgia 30905-5070.

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*This manual supersedes FM 24-18, 13 December 1984.

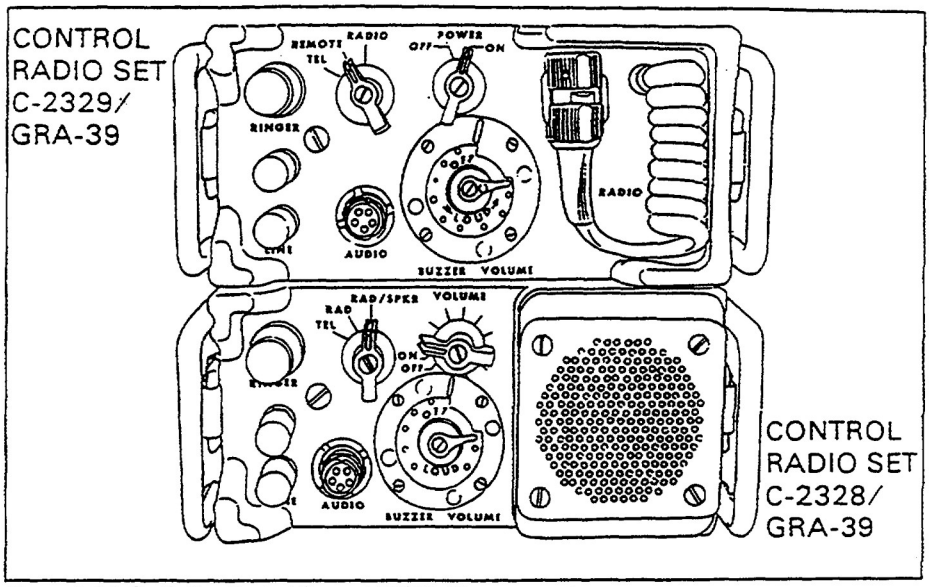

Figure F-14. Radio Set Control Group AN/GRA-39.

NRI call originating from a telephone subscriber.

> NOTE: In the following discussion, you are presumed to be the 1-77 Infantry Battalion NRI operator. The commander of the 1-77 Infantry Battalion desires an NRI call to the commander A/1-77 Infantry Battalion. (Telephone subscriber does not have the radio call signs). Unclassified unit designators will not be linked with call signs.

When a call comes from a telephone network user, your TA-312 buzzer will buzz.

You can answer with either the TA-312 handset or the handset connected to the PHONE jack. Obtain the required information and tell the caller to stand by.

NRI OP: "SERVANT 134".

TEL SUB: "This is SERVANT 106, SERVANT 140 please."

NRI OP: "Roger—Wait—OUT."

> NOTE: NRI operator determines necessary call signs and contacts requested party. In the event the requested party is not operating on your frequency, you must enter his net and request he meet you on your frequency.

NRI OP: "C46, this is A81—OVER."

RADIO SUB: "A81, this is C46—OVER."

NRI OP "This is A81, stand by for A46—OUT."

NOTE: NRI operator provides telephone subscriber with the necessary call signs and reminds him to use proper radiotelephone procedures.

NRI OP: "Sir, you are A46, your party is C46. You must use proper radiotelephone procedures. This circuit is not secure. Go ahead with your call—OUT."

Set the switch on the AN/GSA-7 to RADIO & MON-T.

Any one of three conditions will occur.

The telephone subscriber will be able to control the transmitter from his or her telephone set. This happens if the subscriber's telephone is set for local battery (LB) and is connected to the same switchboard as the NRI rig. In this condition, just monitor the call.

The second possible condition is that the transmitter will key as soon as the switch is moved to RADIO & MON-T for the telephone subscriber to talk and unkeyed by setting the switch to TEL-T for him to listen.

The third possible condition is that the subscriber will be unable to key the transmitter from his or her telephone set and it does not key when the AN/GSA-7 is set to RADIO & MON-T. This occurs if the AN/TTC-38, or SB-3082 *switch is used, or if the call comes over a multichannel system.* In this condition, leave the AN/GSA-7 switch in TEL-T. Key the transmitter with the switch on the TA-312 handset, or the handset connected to the PHONE jack, for the telephone subscriber to talk. Unkey it for the subscriber to listen.

NOTE: If you can find out beforehand what type telephone system is in your area (CB, LB, automatic switch), you should be able to tell how the transmitter is to be keyed.

Monitor the call. If feedback from the speaker causes erratic keying or squealing, turn off the speaker and monitor with the handset.

When the call is over, ring the switchboard operator and tell him or her to *disconnect. Return the switch on the* AN/GSA-7 to TEL-T.

NRI call originating from a radio station.

NOTE: In the following discussion, you are the brigade NRI operator. The B/1-77 Infantry Communications Chief (radio subscriber) desires an NRI call to the 1st Brigade COMSEC Officer. Unclassified unit designator will not be linked with call signs.

If necessary, the radio subscriber requests permission to leave his net.

Radio subscriber contacts the BDE NRI station on the BDE NRI frequency.

RADIO SUB: "W6T81, this is H8Q48—Request permission to enter net—OVER."

NRI OP: "H8Q48, this is W6T81—Identify your station—OVER."

RADIO SUB: "W6T81, this is H8Q48—Refer to Bravo Juliet—OVER."

NOTE: The NRI operator may elect to use abbreviated call signs once the station has been identified.

NRI OP: "Q48, this is T81—authenticate, Juliet Lima—OVER."

RADIO SUB: "T81, this is Q48—I authenticate, Whiskey—OVER."

NRI OP: "This is T81—Roger—OVER."

NOTE: In the event the requested party is not served by the NRI operator's switchboard, the full call sign and item number identifier will be given.

RADIO SUB: "This is Q84—Request contact with T36—OVER."

NRI OP: "This is T81 Roger—Wait—OUT."

NOTE: NRI operator determines switchboard designator and number and establishes contact with requested party.

SWBD OP: "SHAMROCK."

NRI OP: "SHAMROCK 167 please."

TEL SUB: "SHAMROCK 167."

NRI OP: "This is SHAMROCK 134. You have a radio call from H8Q48. Refer to Bravo Juliet. You are T36. You must use proper radiotelephone procedures. This circuit is not secure. Do you have any questions? Stand by—OUT."

NRI OP: "Q48, this is T81. Go ahead with your Call—OUT."

Switch the AN/GSA-7 to RADIO & MON-T. Refer to the previous sequence for difference in transmitter keying with CB, LB, or automatic switches.

When the call is completed, return the AN/GSA-7 switch to TEL-T. Ring the switchboard to tell him to disconnect the call.

Using the AN/GRA-39.

NRI hookup. The following equipment will be needed: Radio Set Control Group AN/GRA-39, Switchboard SB-22/PT, Radio Set AN/VRC-49 or Receiver-Transmitter RT-524, 18 Batteries BA-30/U, Connector U-182/U or Connector U-229/U, and 1 meter (about 3 feet) of 2-wire cable. Have your

F-14. Location

This equipment is designed to be mounted in a vehicle along with the radio set with which it is being used. Space requirements are illustrated in Figure F-20. When the C-6709/G is used with some radio sets (such as the AN/VRC-12), it uses the radio set power supply. In some cases, an external 24 volts DC power supply is needed. The C-6709/G is normally mounted so the operator has easy access to the radio set. The use of an external 24 volts DC power supply will be required when using any radio/crypto sets other than the AN/VRC-12. The connection for these radio/crypto sets will be made to a pair of binding posts on the front panel of the C-6709/G. The wire/cable and the connectors (for example, alligator clips for 24 volts DC vehicle battery) are not supplied as a component with the equipment when used with the list of radio/crypto sets other than the AN/VRC-12.

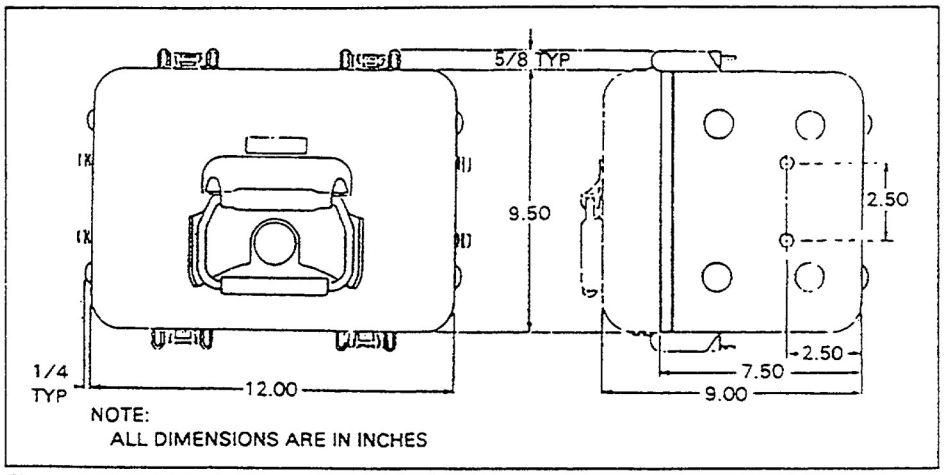

Figure F-20. Vehicle space requirements for C-6709.

F-15. Operation

Call originating from a radio station.

NOTE: In the following discussion you are the 1-77 Infantry Battalion NRI operator. The Commander, 1-77 Infantry Battalion desires an NRI call to the Commander A/1-77 Infantry Battalion. (Telephone subscriber does not have the Radio call signs.) Unclassified unit designators will not be linked with call signs.

You receive a call from a radio station. You will hear the call in your H-250 handset or H-325 headset microphone. You may hear the call over the radio speaker, if the radio set is so equipped.

RADIO SUB: "A81, this is A46—OVER."

If the C-6709/G has been placed in the proper standby condition, you need only to key the transmitter to answer the call. If you are using the H-250 handset, key the radio by depressing the push-to-talk (PTT) switch and unkey it by releasing the PTT switch. If you are using the H-325/TTC headset microphone, you key the radio by depressing key number 1 on the C-6709/G keysender and unkey by depressing key number 3. If the C-6709/G is not in the proper standby condition, you must place the C-6709/G MODE switch to the OPER position; this permits you to key your radio on and off. You next depress the C-6709/G OPER CONNECT RADIO pushbutton; this connects the C-6709/G to the NRI transmitter-receiver. You may now key your radio on and off as outlined above.

NRI OP: "This is A81—OVER."

NOTE: In the event the requested party is not served by the NRI operator's switchboard, the full call sign and item number identifier will be given.

RADIO SUB: "This is A46. Request contact with C46—OVER."

NRI OP: "This is A81—Roger—Wait—OUT."

You consult the SOI and telephone directory to determine the telephone number for the desired party.

You depress the C-6709/G OPER CONNECT SWBD pushbutton; this connects the C-6709/G to the automatic switchboard. The C-6709/G SVC REQ/BUSY lamp will come on and remain lit and you will receive a dial tone from the switchboard. You then key the number of the desired party on the keysender of the C-6709/G.

NOTE: If you misdial the number, depress the C-6709/G RLSE pushbutton; this disconnects the C-6709/G from the switchboard and places it in a standby condition. The C-6709/G SVC REQ/BUSY lamp will go out. Again depress the C-6709/G OPER CONNECT SWBD pushbutton and proceed as above.

When the telephone is answered, get the desired party on the line and tell him or her there is an incoming NRI call. Because a telephone user doesn't usually have an SOI, you will have to give the subscriber the call sign to use. You and the subscriber now must determine the type of radio transmitter keying control the subscriber will use. If the subscriber is using a telephone handset that has a push-to-talk (PTT) switch, the SF (PTT) position of the C-6709/G MODE switch may be used. In this position the transmitter is keyed when the PTT switch is depressed and held, and is unkeyed when the PTT switch is released. If the subscriber has a telephone with a keysender, the DTMF 1/3 position of the C-6709/G MODE switch may be used. In this position, the transmitter is keyed when the subscriber presses key number 1 on the keysender and is unkeyed when key number 3 is pressed. The subscriber may choose, as an alternative, to use the AVOX position of the C-6709/G MODE switch. In this position, the transmitter is keyed when the subscriber is speaking and is unkeyed when he or she is silent. You must remember the type of transmitter control used. The switchboard subscriber is then told to stand by for the NRI call.

TEL SUB: "SERVANT 140."

NRI OP: "This is SERVANT 134. You have a call from A46. What type of telephone equipment are you using?"

TEL SUB: "TA-312."

NRI OP: "Your call is from A46. You are C46. You must use proper radiotelephone procedure. This circuit is not secure. Stand by—OUT."

You depress the C-6709/G OPER CONNECT RADIO pushbutton; this transfers the connection of the NRI operator from the switchboard subscriber to the radio transmitter.

NOTE: The C-6709/G SVC REQ/BUSY lamp will remain lit, indicating that the C-6709/G is still connected to the switchboard subscriber. Using the H-250 handset or H-325/TTC headset microphone, establish contact with the radio station. Tell the radio subscriber to then go ahead with the call.

NRI OP: "A46 this is A81. Go ahead with your call—OUT."

You set the C-6709/G MODE switch to the AVOX position.

NOTE: At this time the C-6709/G MODE switch will be set to one of the three positions, as determined by you and the switchboard subscriber.

You then depress the C-6709/G CALL CONNECT OPER IN pushbutton. This disconnects you from the switchboard subscriber, and connects the switchboard subscriber and the radio station to a common talk path within the C-6709/G. When the C-6709/G CALL CONNECT OPER IN pushbutton is depressed, you can monitor both sides of the NRI talk path. You cannot transmit to either party.

Monitor the NRI talk path to ensure that the switchboard subscriber can key the transmitter on and off and that good communications between the two parties has been established. If for some reason the switchboard subscriber cannot key the transmitter, you must set the C-6709/G MODE switch to the OPER position and key the transmitter on and off at the appropriate times for the switchboard subscriber. After a good NRI connection has been made, you must monitor to ensure proper radio procedure is being used.

NOTE: As long as the NRI call is in progress, the C-6709/G SVC REQ/BUSY lamp will remain lit.

When the NRI call has been completed and the switchboard subscriber hangs up the handset, the C-6709/G SVC REQ/BUSY lamp will go out, and the C-6709/G is automatically placed in a standby condition. When this occurs, you should place the C-6709/G MODE switch to the OPER position and depress the OPER CONNECT RADIO pushbutton. You are now ready to answer the next service request. If it is by radio, you need only key the transmitter to answer. If the request is by telephone, you need only to depress the C-6709/G OPER CONNECT SWBD pushbutton to answer.

If the C-6709/G SVC REQ/BUSY lamp does not go out within a reasonable time, you should depress the C-6709/G CALL CONNECT OPER IN pushbutton. This will enable you to monitor the NRI talk path. If the call has been completed, you should then depress the C-6709/G RLSE pushbutton. This will disconnect the C-6709/G from the switchboard and place the C-6709/G into a standby position. You should then place the C-6709/G MODE switch to the OPER position and depress the OPER CONNECT RADIO pushbutton. You are then ready for the next service request, as outlined above.

Call originating from switchboard subscriber.

You receive a call from a switchboard subscriber. This is indicated on the C-6709/G by the audible alarm and flashing SVC REQ/BUSY lamp.

Depress the C-6709/G OPER CONNECT SWBD pushbutton. This connects you to the switchboard subscriber. The audible alarm will go off and the SVC REQ/BUSY lamp stops flashing and remains lit.

Answer the call by using the H-325/TTC headset microphone or H-250 handset. Obtain from the subscriber the individual or station the caller desires. Because a telephone user does not usually have a CEOI, you will have to look up the call signs and frequency and give the call sign to the subscriber. You and the subscriber will have to determine the type of radio transmitter keying control the subscriber will use. If the subscriber is using a telephone that has a push-to-talk switch, the SF (PTT) position of the C-6709/G MODE switch may be used. In this position the transmitter is keyed when the PTT switch is depressed and held, and is unkeyed when the PTT switch is released. If the subscriber has a telephone with a keysender, the DTMF 1/3 position of the C-6709/G MODE switch may be used. In this position, the transmitter is keyed when the subscriber depresses key number 1 on the keysender and is unkeyed when the subscriber depresses key number 3. Alternately, the subscriber may choose to use the AVOX position of the C-6709/G MODE switch. In this position the transmitter is keyed when the subscriber speaks and is unkeyed when he or she is silent. Remember the type of transmitter control used. Tell the switchboard subscriber to standby while the desired party is contacted by radio.

NRI OP:	"SERVANT 134."
TEL SUB:	"This is SERVANT 106, connect me with SERVANT 140."
NRI OP:	"What type of telephone equipment are you using?"
TEL SUB:	"TA-838."
NRI OP:	"Roger—Wait—OUT."

Depress the C-6709/G OPER CONNECT RADIO pushbutton. This transfers you from the switchboard subscriber to the NRI radio receiver-transmitter. Note that the C-6709/G SVC REQ/BUSY lamp will remain lit, indicating that the C-6709/G is still connected to the switchboard subscriber. Set the radio to the frequency of the desired party. Place the C-6709/G MODE switch in the OPER position. You may now key the radio on and off. If you are using handset H-250, key the radio by pressing the PTT switch

and unkey the radio by releasing the PTT switch. If you are using headset microphone H-325/TTC, the transmitter is keyed when you depress key number 1 on the C-6709/G keysender and is unkeyed when you depress key number 3.

NRI operator determines necessary call signs and contacts requested party. In the event the requested party is not operating on your frequency, you must enter his net and request he meet you on your frequency.

NRI OP: "C46, this is A81—OVER."

RADIO SUB: "This is C46—OVER."

NRI OP: "This is A81—Stand by for a call from A46—OUT."

Depress the C-6709/G OPER CONNECT SWBD pushbutton. This disconnects you from the receiver-transmitter and makes connection to the switchboard subscriber. Provide the telephone subscriber with the necessary call signs and remind him to use proper radiotelephone procedure.

NRI OP: "Sir, you are A46. Your party is C46. You must use proper radiotelephone procedure. This circuit is not secure. Go ahead with your call—OUT."

Set the C-6709/G MODE switch to the AVOX position.

NOTE: At this time the C-6709/G MODE switch will be set to one of the three positions, as determined by you and the switchboard subscriber earlier.

Depress the C-6709/G CALL CONNECT OPER IN pushbutton. This disconnects you from the switchboard subscriber, and connects the switchboard subscriber and radio station to a common talk path within the C-6709/G. When the C-6709/G CALL CONNECT OPER IN pushbutton is depressed, you can monitor both sides of the NRI talk path. You cannot transmit to either party.

Monitor the NRI talk path to ensure that the switchboard subscriber can key the transmitter on and off and that good communications between the two parties has been established. If for some reason the switchboard subscriber cannot key the transmitter, you must set the C-6709/G MODE switch to the OPER position and key the transmitter on and off at the appropriate times for the switchboard subscriber. After a good NRI connection has been made, you must monitor to ensure proper radio procedure is being used.

NOTE: As long as the NRI call is in progress, the C-6709/G SVC REQ/BUSY lamp will remain lit.

When the NRI call has been completed and the switchboard subscriber hangs up the handset, the C-6709/G SVC REQ/BUSY lamp will go out. The C-6709/G is automatically placed in a standby condition. When this occurs, place the C-6709/G MODE switch to the OPER position and depress the OPER CONNECT RADIO pushbutton. You are now ready to answer the next service request. If it is by radio, you need only to key the transmitter to answer. If the request is by telephone, you need only to depress the C-6709/G OPER CONNECT SWBD pushbutton to answer.

If the C-6709/G SVC REQ/BUSY lamp does not go out within a reasonable time, depress the C-6709/G CALL CONNECT OPER IN pushbutton. This will enable you to monitor the NRI talk path. If the call has been completed, depress the C-6709/G RLSE pushbutton. This will disconnect the C-6709/G from the switchboard and place the C-6709/G into a standby condition. Place the C-6709/G MODE switch to the OPER position and depress the OPER CONNECT RADIO pushbutton. You are now ready for the next service request as outlined above.